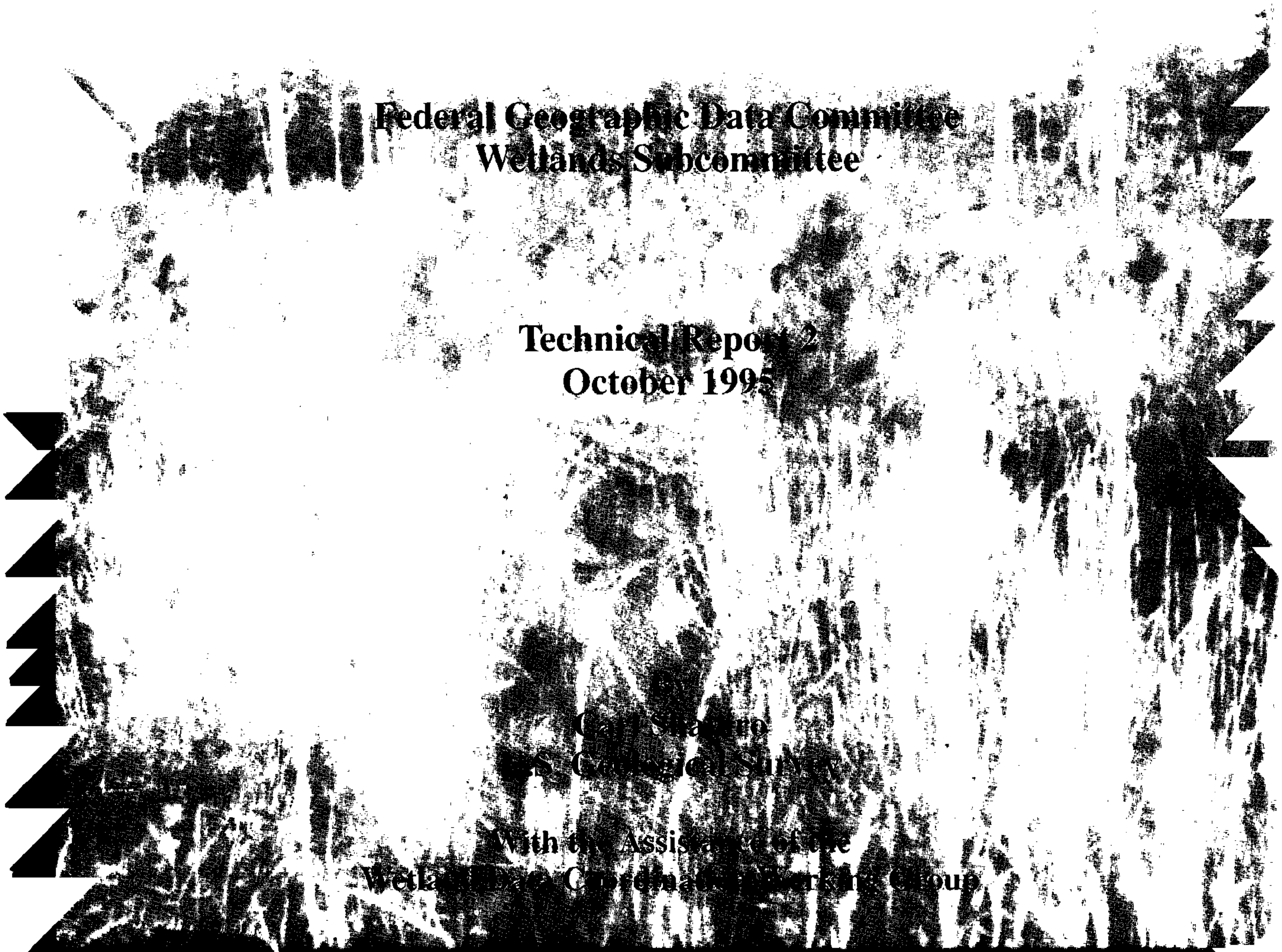
COORDINATION AND INTEGRATION OF WETLAND DATA FOR STATUS AND TRENDS AND INVENTORY ESTIMATES

Progress Report



Federal Geographic Data Committee
Wetlands Subcommittee

Technical Report 2
October 1995

Carl Shapiro
U.S. Geological Survey

With the Assistance of the
Wetlands Data Coordination Working Group

Federal Geographic Data Committee

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Introduction

For the past 2 years, the Wetland Data Coordination Working Group of the Federal Geographic Data Committee (FGDC) Wetlands Subcommittee has been implementing a strategy to better coordinate government collection of wetland data used for developing status and trends and inventory estimates.[1]

The working group's strategy was developed in response to two recommendations contained in the December 1990 "Report of the Wetland Inventory Subgroup of the Domestic Policy Council's Interagency Wetlands Task Force."[2] On August 24, 1993, in the Clinton Administration's policy document on wetlands, the White House Office on Environmental Policy announced that "the Administration will ... direct the Wetlands Subcommittee of the Federal Geographic Data Committee to complete reconciliation and integration of all Federal agency wetland inventory activities."

The working group includes representatives from the U.S. Department of the Interior (U.S. Fish and Wildlife Service (FWS) and U.S. Geological Survey (USGS)), the U.S. Department of Agriculture (Natural Resources Conservation Service (NRCS)), the U.S. Department of Commerce (National Oceanic and Atmospheric Administration (NOAA)), the Environmental Protection Agency (EPA), and the State of Maryland's Water Resources Administration (MD-WRA).[3]

[1]The strategy is described in "Strategic Interagency Approach to Developing a National Digital Wetlands Database (Second Approximation)," summer 1994, Wetlands Subcommittee, Federal Geographic Data Committee.

[2]The two recommendations are (1) "Coordinate/integrate the Fish and Wildlife Service's Statistical Wetlands Status and Trends Surveys with the Soil Conservation Service's National Resource Inventory;" and (2) "Coordinate/integrate the Fish and Wildlife Services's National Wetlands Inventory mapping program with the Soil Conservation Service's wetland determinations made for the wetland conservation (Swampbuster) provision of the Food Security Act."

[3]The MD-WRA joined the working group when a pilot evaluation began in Wicomico County, Md. It is hoped that as the working group's efforts proceed, other State organizations will participate in its activities.

The strategy includes four sequentially ordered tasks designed to improve the coordination of government wetland data collection and to evaluate whether changes in data collection techniques and responsibilities can improve the Government's ability to meet national needs.

Tasks 1 and 2 were completed in September 1992 and were documented in a report (unpublished) forwarded to the Chair, FGDC, on September 24, 1992. Task 1 involves the integration of terminology, definitions, and classification systems used by government organizations collecting wetland data. Task 2 involves the coordination of government wetland data collection processes and reports.

At this time, the working group is implementing task 3A, which relates to the consistency of wetland data collected by various government organizations. Wetland data of different types and accuracy are collected by many government organizations, including the FWS, the NRCS, NOAA, EPA, and the USGS, as well as by many State agencies. The purpose of task 3A is to identify the level of consistency among wetland data collected by various government organizations and to determine possible causes of inconsistencies. The results of this evaluation should help government organizations reconcile their data so that the Nation can better understand and use available wetland data and information.

The working group plans to evaluate wetland data from as many as 10 counties with varying wetland density and complexity. The following 10 counties tentatively chosen for study were selected to ensure diversity in wetland, geographic, and other characteristics:

Wicomico, Md.	Dade, Fla.
Logan, N.Dak.	Washington, N.C.
Terrebone, La.	Camden, N.C.
Meade, Kans.	Penobscot, Maine
Yazoo, Miss.	Tulare, Calif.

Wicomico County, Maryland, Pilot Study

The working group began a pilot study to better understand the issues and problems associated with the data comparison task. Wicomico County, Md.

was selected as the pilot because (1) wetland data and other spatial data in digital form are available from the various government agencies, (2) the county's proximity to the Washington, D.C., area facilitates field analysis where necessary, and (3) the county has an abundance of forested wetlands, which are generally recognized as the most difficult wetland type to map.

In the Wicomico County study area, wetland data were compared from the FWS National Wetlands Inventory (FWS-NWI), the NRCS Wetlands Inventory (NRCS-WI)[4], the NRCS National Resources Inventory (NRCS-NRI), the NOAA Coastal Change Analysis Program (NOAA-C-CAP), and the MD-WRA. The USGS Mapping Applications Center helped the working group implement the analysis using geographic information system (GIS) technology. The analysis in the Wicomico County pilot study was designed to provide information on two primary issues: (1) the level of consistency among the various government wetland data sets; and (2) the relative strengths and weaknesses among the data sets.

To determine the level of consistency among the various government wetland data sets, the working group compared the total acreage in the Wicomico County study area that each data set classifies as wetland and the acreage within various systems or subcategories of wetlands. Although acreage comparisons are important for evaluating national wetland acreage projections, this type of comparison is an inadequate indicator of consistency. Even though total acreage classified as wetlands may be similar amounts, the various data sets may classify different areas within the study area as wetlands.

To resolve this problem, the working group developed and examined a series of maps and the associated tabular data summaries showing areas of agreement and disagreement in wetland delineation among the various data sets.

Tests to determine the relative strengths and weaknesses of government wetland data sets are difficult because there is no standard of correct wetland classification with which to compare the various data sets. That

[4]During the latter part of 1994, the Soil Conservation Service (SCS) became the Natural Resources Conservation Service (NRCS). For consistency in this report, the organization is referred to as the NRCS, even for events that occurred prior to the change. Publications, however, are cited by the original name.

is, if there is an inconsistency among the data sets in wetland classification, data do not exist to resolve the inconsistency.

To obtain independent information on whether a site was actually a wetland or an upland, the working group collected field data in the Wicomico County study area and compared them with the wetland delineations from the various government data sets. Two tests were conducted to develop information on the relative strengths and weaknesses of the government data sets.

The first test involved examining 130 points in the field in the Wicomico County study area to determine whether wetlands or uplands existed at the points. The working group selected the points because of inconsistencies in wetland classification among the data sets at the points and to resolve questions relating to wetland identification. An independent contractor with expertise in wetlands identification collected the data at the 130 points in the field in May and June 1993.

Because many of the points selected in the first test were found to be near wetland boundaries, a second test was designed to examine a series of points along transects so that the impact of boundary changes could be assessed. The working group selected the transects on the basis of inconsistencies among the wetland data sets or to study other issues they had identified. A field team from the working group collected data in July 1993 on wetland delineation, as well as on soils, vegetation, and hydrology.

Conclusions

The case study in Wicomico County, Md., provides evidence that supports two principal hypotheses: (1) there is significant disagreement in wetland delineation among the various government wetland data sets; and (2) there are substantial differences in the strengths and weaknesses of the wetland data sets evaluated. These strengths and weaknesses relate to the effectiveness of the data sets in identifying all wetland areas as wetlands, and (or) in delineating only wetland areas as wetlands. The results reported in this paper are derived from a case study in one county; additional data and analysis are required to evaluate these hypotheses conclusively. That is, the issues raised in this case study merit attention and analysis beyond Wicomico County.

Data Inconsistency

The four data sets with polygon data, FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI, disagree in more than 90 percent of the area that at least one of the four data sets delineates as wetland. This disagreement is not just about wetland classes or systems, but rather about the fundamental question of whether or not an area is a wetland.

The NRCS-WI accounts for more than 70 percent of the area that only one of the four data sets delineates as wetland. This is not surprising because data for the NRCS-WI are collected for regulatory purposes and collection procedures are designed not to miss possible wetland areas. When the three other data sets with polygon data are compared, they continue to disagree among themselves in about 80 percent of the area that at least one of the three data sets delineates as wetland. In fact, in comparisons between any two of the data sets with polygon data, there is disagreement in more than 50 percent of the area that at least one of the two data sets delineates as wetland. Again, this disagreement is not about wetland classes or systems, but rather about whether or not an area is a wetland.

Comparisons between the NRCS-NRI, which has point data, and the four data sets with polygon data produce similar results. In these comparisons, there is disagreement in more than 99 percent (103 out of 104) of the points that are classified by at least one data set as wetland.

There are several possible explanations for this high level of disagreement or inconsistency among the data sets. First, it is important to emphasize that the results presented in this analysis represent data from just one county. A distinguishing factor in Wicomico County, Md., is the fact that a high proportion of the wetlands are palustrine forested.[5] Previous studies

[5]Three of the data sets with polygon data, FWS-NWI, MD-WRA, and NOAA-C-CAP, distinguished palustrine wetlands from other wetlands. All of the three data sets classified as palustrine more than 80 percent of the wetlands that they had delineated. The FWS-NWI and MD-WRA classified wetlands to the Cowardin and others (1979) class level and delineated more than 80 percent of the palustrine wetlands as forested.

have noted the difficulty in identifying wetlands when using remote sensing techniques in forested areas.[6]

The results from the analysis show that much of the disagreement among the data sets occurs in areas that at least one data set classifies as palustrine wetland. Significantly, this disagreement occurs even between data from FWS-NWI and MD-WRA, which use identical classification systems and similar aerial photography photointerpretation techniques.[7]

Although most of the disagreement occurs in areas that at least one data set classifies as palustrine, the level of agreement among data sets is much greater for wetland types other than palustrine. For instance, more than 90 percent of the area classified as lacustrine, riverine, or estuarine wetlands by FWS-NWI are also classified as wetlands by MD-WRA.

Much of the disagreement among the data sets may be related to the spatial accuracy of the data. When 50-meter buffers are created around the NRCS-NRI points that are delineated by at least one of the data sets as wetlands, the level of agreement potentially rises from less than 1 percent to approximately 41 percent. This implies that there may be problems associated with the spatial registration of the data in some or all of the data sets. It should be emphasized, however, that even with these 50-meter buffers, there is still disagreement among the five data sets at almost 60 percent of the points that have been delineated by at least one data set as wetland.

The difficulties in identifying palustrine forested wetlands that were demonstrated in this case study raise the question of whether a new category of wetlands that encompasses mixed wetland and upland areas would be helpful in understanding the characteristics and ambiguities in some of these areas. Such a category of wetlands could reduce the level of inconsistency among wetland data sets because larger parcels of land could be classified as mixed wetland

[6]See for instance, "Use of High-Altitude Aerial Photography for Inventorying Forested Wetlands in the United States," by Ralph W. Tiner, Jr. "Forest Ecology and Management," 33/34 (1990), p. 593-604. Also, see "Results of Field Reconnaissance of Remotely Sensed Land Cover Data," 1991.

[7]Subsequent to this analysis, FWS-NWI has updated data for four of the 7.5-minute quadrangles within the study area.

and upland areas without the need to distinguish explicitly where small interspersed wetland and upland areas begin and end.

Data Set Strengths and Weaknesses

Errors in the delineation of wetlands can be classified into two distinct categories: Type I errors, or errors of omission, and type II errors, or errors of commission. Type I errors occur when a wetland is delineated in a data set as an upland. Type II errors occur when an upland is delineated as a wetland.

The results from the field tests provide evidence that in the study area, FWS-NWI and MD-WRA are more conservative in the delineation of wetlands than are NRCS-WI and NOAA-C-CAP and are more likely to commit type I errors, or errors of omission. The results also show that in the study area, NRCS-WI and NOAA-C-CAP delineate more area as wetlands and are more likely to commit type II errors, or errors of commission.

Information on the type of error that is likely to be associated with a particular wetland data set is important both for interpreting wetland data and for improving the effectiveness of data collection efforts. By knowing the type of error associated with a particular data set, data users can choose the data set that best suits their needs. That is, choices can be made on which data set is best suited for a specific problem depending on whether it is more important to identify every wetland area or if it is important that wetlands delineated are actually wetlands.

Future Plans

The case study described in this analysis is part of an ongoing effort by the FGDC Wetlands Subcommittee to improve the coordination of government wetland data collection and to evaluate whether changes in data collection techniques and responsibilities can improve the Government's ability to meet national needs. The working group began a wetland data comparison in Logan County, N.Dak., during the summer of 1994. This effort builds upon the work begun in Wicomico County and deals with similar issues. An additional data set comparison is scheduled to begin in Dade County, Fla., during 1995.

The implementation of task 3B and task 4 will also begin during 1995. Task 3B concerns the consistency of wetland statistical results and includes the development of a method to compare the results developed by the various government organizations reporting on wetland status and trends. Task 4 builds on the results of the first three tasks and includes an evaluation of the feasibility and the public policy implications of wetland data integration. This evaluation is expected to address the benefits and costs associated with various levels of wetland data accuracy and timeliness so that these issues can be incorporated into a comprehensive national strategy for wetland data collection.

Introduction

I. Introduction

A. Overview

For the past 2 years, the Wetland Data Coordination Working Group of the Federal Geographic Data Committee (FGDC) Wetlands Subcommittee has been implementing a strategy to better coordinate government collection of wetland data used for developing status and trends and inventory estimates (FGDC Wetlands Subcommittee, 1994). This report documents the working group's progress.

The working group's strategy was developed in response to two recommendations contained in the December 1990 "Report of the Wetland Inventory Subgroup of the Domestic Policy Council's Interagency Wetlands Task Force."[1] Implementation of the strategy was assigned to the FGDC Wetlands Subcommittee on July 10, 1992, by the Chair, FGDC. On August 24, 1993, in the Clinton Administration's policy document on wetlands, the White House Office on Environmental Policy announced that "the Administration will ... direct the Wetlands Subcommittee of the Federal Geographic Data Committee to complete reconciliation and integration of all Federal agency wetland inventory activities" (White House Office on Environmental Policy, 1993).

The working group includes representatives from the U.S. Department of the Interior (U.S. Fish and Wildlife Service (FWS) and U.S. Geological Survey (USGS)), the U.S. Department of Agriculture (Natural Resources Conservation Service (NRCS)), the U.S. Department of Commerce (National Oceanic and Atmospheric Administration (NOAA)), the

[1]The two recommendations are (1) "Coordinate/integrate the Fish and Wildlife Service's Statistical Wetlands Status and Trends Surveys with the Soil Conservation Service's National Resource Inventory;" and (2) "Coordinate/integrate the Fish and Wildlife Services's National Wetlands Inventory mapping program with the Soil Conservation Service's wetland determinations made for the wetland conservation (Swampbuster) provision of the Food Security Act."

Environmental Protection Agency (EPA), and the State of Maryland's Water Resources Administration (MD-WRA).[2]

The strategy includes implementing four sequentially ordered tasks designed to improve the coordination of government wetland data collection and to evaluate whether changes in data collection techniques and responsibilities can improve the Government's ability to meet national needs.

Tasks 1 and 2 were completed in September 1992 and were documented in a report (unpublished) forwarded to the Chair, FGDC, on September 24, 1992. Task 1 involves integrating terminology, definitions, and classification systems used by government organizations collecting wetland data. Task 2 involves coordinating government wetland data collection processes and reports.

At this time, the working group is implementing task 3A, which relates to the consistency of wetland data collected by various government organizations. The purpose of this task is to understand better the level of consistency among wetland data sets. Where inconsistencies in data exist, the working group's goal is to identify causes of the inconsistencies and to propose improvements in government data collection efforts. The results of this evaluation should help government organizations reconcile their data so that the Nation can better understand and use available wetland data and information.

Tasks 3B and 4 are scheduled to begin during 1995. Task 3B concerns the consistency of wetland statistical results and includes the development of a method to compare the results developed by the various government agencies reporting on wetland status and trends. Task 4 builds on the results of the first three tasks and includes an evaluation of the feasibility and the public policy implications of further wetland data coordination and integration. This evaluation is expected to address the benefits and costs associated with various levels of wetland data accuracy and timeliness so that these issues can be incorporated into a comprehensive strategy for wetland data collection.

[2]The MD-WRA joined the working group when a pilot evaluation in Wicomico County, Md. began. It is hoped that as the working group's efforts proceed, other State organizations will participate in its activities.

B. Background[3]

Wetland data of different types and accuracy are collected by many government organizations, including the FWS, the NRCS, NOAA, EPA, and the USGS, as well as by many State agencies. A summary description of the wetland data collection activities of the organizations participating in the working group's activities follows. More detailed descriptions are included in appendix 1.

1. U.S. Fish and Wildlife Service

The FWS, through its National Wetlands Inventory Program (FWS-NWI), collects wetland inventory information and estimates the status and trends of the Nation's wetland resources.

Inventory information is needed to assess the effects of site-specific projects, including resource management plans, environmental impact assessments, facility and corridor siting, oil spill contingency plans, natural resource inventories, and habitat surveys. The inventory identifies the location, size, shape, and other characteristics of wetlands and deepwater habitats. The FWS-NWI publishes the inventory information on 1:24,000-scale 7.5-minute quadrangle USGS base maps (1:63,360 scale in Alaska).

The Emergency Wetlands Resources Act of 1986 requires FWS-NWI to complete wetland maps for the contiguous United States by the end of fiscal year 1998. The act was amended in 1992 to require FWS-NWI to complete wetlands maps for the approximately 3,000 15-minute quadrangles in Alaska and other noncontiguous areas of the Nation by September 30, 2000. To date, FWS-NWI has completed 84 percent of the wetland maps for the lower 48 States and 28 percent of the wetland maps for Alaska. The 1992 amendments to the Emergency Wetlands Resources Act require FWS-NWI to convert its wetland map information into a digital data base by September 30, 2004.

[3]Much of the information contained in this section is derived from and is available in more detail in "Federal Coastal Wetland Mapping Programs," edited by Sari J. Kiraly, Ford A. Cross, and John D. Buffington, U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C. 20240, Biological Report 90 (18), December 1990.

Currently, data for 25 percent of the lower 48 States and 3 percent of Alaska are available in digital form.[4]

Information on the status and trends of the Nation's wetland resources are needed to evaluate the effectiveness of existing Federal programs and policies and to identify national and regional trends. The FWS-NWI uses statistical techniques to calculate, from a sample, the status of the Nation's wetlands and estimates of gains and losses. Data for the FWS-NWI status and trends report (FWS-SAT) are collected independently from the inventory portion. Different conventions are used, but the data collection techniques are similar.

The FWS-NWI has provided Congress with three reports on wetland status and trends. The Emergency Wetlands Resources Act of 1986 requires FWS-NWI to update wetland status and trends reports every 10 years. The last update, which was published in 1991, covered changes occurring from the mid-1970's to the mid-1980's. The next report is due in 2000.

2. Natural Resources Conservation Service[5]

The NRCS also collects wetland inventory information and estimates the status and trends of the Nation's wetland resources on non-Federal lands.

The wetland conservation (Swampbuster) provision of the Food Security Act (FSA) of 1985, amended by the Food, Agriculture, Conservation, and Trade Act of 1990, requires the U.S. Department of Agriculture (USDA) to deny program benefits to agricultural producers that drain and cultivate

[4]The 1992 amendments to the Emergency Wetlands Resources Act direct FWS-NWI to archive wetland maps and to make the maps and digital data products available for dissemination. Final NWI maps are stored in the National Archives. The FWS-NWI wetland maps and digital data products are sold by the USGS through its "800" telephone number (1-800-USA-MAPS) and at seven USGS Earth Science Information Centers. Wetland maps are also sold at 31 State distribution centers. The FWS-NWI distributes microfiche copies to Map Depository Libraries through the Federal Depository Library Program.

[5]During the latter part of 1994, the Soil Conservation Service (SCS) became the Natural Resources Conservation Service (NRCS). For consistency in this report, the organization is referred to as the NRCS, even for events that occurred prior to the change. Publications, however, are cited by the original name.

wetlands for agricultural production. The NRCS Wetland Inventory (NRCS-WI), begun in 1988, is combined with other data sources to identify FSA wetlands and converted wetlands so that the Agricultural Stabilization and Conservation Service, the Farmers Home Administration, and the Federal Crop Insurance Corporation can determine producer eligibility for their respective programs. The NRCS-WI "focuses on inland freshwater wetlands that have a high potential for agricultural conversion". The NRCS estimates that "the conversion of wetlands to agricultural land has accounted for more than 80 percent of the Nation's wetland loss".[6]

The August 24, 1993, Clinton administration policy on wetlands designates NRCS-WI as "the final government position on the extent of Swampbuster and Clean Water Act jurisdiction on agricultural lands" (White House Office on Environmental Policy, 1993). On January 6, 1994, the NRCS signed a Memorandum of Agreement (MOA) with the Army Corps of Engineers, the FWS, and EPA to implement this policy. According to the MOA, the NRCS will be certifying previous wetland determinations made for the FSA to ensure that they are consistent with current wetland criteria. In the future, the NRCS will take the lead in wetland delineation on agricultural lands for both the Swampbuster and the Clean Water Act (Section 404) programs.

The Rural Development Act of 1972 directs the Secretary of Agriculture to carry out a land inventory and monitoring program and to issue a report that reflects soil, water, and related resource conditions at not less than 5-year intervals. The National Resources Inventory (NRCS-NRI) is a multi-resource inventory based on soils and other resource data collected at 800,000 sample sites located throughout the Nation. Some of the 800,000 sample sites are evaluated as part of each NRCS-NRI every 5 years. For instance, the 1987 NRCS-NRI involved the evaluation of nearly 300,000 sample points. The data collected for the NRCS-NRI are not mapped; rather, they are used in a statistical estimation process to develop information about the Nation's resources.

[6]"Soil Conservation Service's Wetland Inventory," by Billy M. Teels, included in "Federal Coastal Wetland Mapping Programs," p. 93.

Information generated in the NRCS-NRI is used for land conservation, use, and development; guidance of community development for balanced rural-urban growth; identification of prime agricultural areas; and protection of the quality of the environment. The Soil and Water Conservation Act of 1977 and the FSA of 1985 also provide direction to NRCS-NRI. The NRCS-NRI assists NRCS in ascertaining the effectiveness of its programs and policies by monitoring the status of wetland use and conversion on non-Federal lands.

As a part of the NRCS-NRI, NRCS estimates wetland acreage and trends in wetland acreage. Wetland status and trends in non-Federal rural areas throughout the United States, except for Alaska, were estimated in the 1977, 1982, and 1987 NRCS-NRI's. The wetland part of the NRCS-NRI was last updated in a special 1991 study.[7] The latest NRI data base, expected to be available during 1995, allows analysis of wetland changes between 1982 and 1992, relative to soils, land use, and many other factors. This analysis evaluates wetland status and trends in non-Federal urban and rural areas.

3. National Oceanic and Atmospheric Administration

In 1990, NOAA began the Coastal Change Analysis Program (NOAA-C-CAP) to monitor coastal wetlands, including submerged aquatic vegetation and adjacent upland cover and change. NOAA plans to collect wetland inventory information and to estimate wetland status and trends in coastal areas as C-CAP progresses. The first study completed by NOAA-C-CAP was in the Chesapeake Bay area.

The Magnuson Fishery Conservation and Management Act of 1976, with amendments, requires NOAA to (1) identify and describe the habitat requirements of fish stocks, (2) identify existing habitat conditions and sources of pollution and degradation, (3) conduct habitat protection and enhancement programs, and (4) recommend measures to protect and manage habitats. The goal of NOAA-C-CAP is to determine how land cover and changes in land cover and habitat affect living marine resources, including their abundance,

[7]The special 1991 wetlands update was based on data from 20,000 scientifically selected sample sites that were also included in the 1982 and 1987 NRI's. The update resulted in a revised estimate of wetland loss on non-Federal rural lands.

distribution, and health. In addition to determining the quantity of wetlands in coastal regions of the United States, NOAA-C-CAP plans to emphasize the determination of wetland quality, including biomass, productivity, and functional status.[8]

NOAA-C-CAP plans to develop a comprehensive, nationally standardized information system for land and habitat cover and change in the coastal region of the Nation. Since 1990, NOAA-C-CAP has worked primarily on developing a standardized protocol through a series of regional workshops and meetings with other Federal, State, and academic personnel. NOAA-C-CAP intends to examine the Nation's coastal region at intervals ranging from 1 to 5 years. Areas disturbed by extreme events, such as oil spills or hurricanes, will be monitored annually, and areas with intense development, every 2 or 3 years; other coastal areas will be monitored every 5 years.

4. Environmental Protection Agency

The EPA uses wetland maps, statistics on wetland extent status and trends, and information on status and trends in wetland function and condition. The two main programs using wetlands information in EPA are the Office of Water, which houses EPA's Wetlands Division, and the Office of Research and Development, which sponsors the Environmental Monitoring and Assessment Program (EPA-EMAP).

The EPA uses wetland data produced by other agencies, usually FWS, rather than generate its own wetland maps. However, EPA sometimes carries out its own localized, project-specific wetland mapping when existing sources are not sufficiently detailed or up to date. These data, as well as FWS-NWI maps, are used to support wetlands advance identification and planning, enforcement actions, individual research projects, and other actions.

The EPA-EMAP monitors the condition of freshwater and estuarine wetlands, as well as surface waters in defined regions of the country. The EPA-EMAP is coordinating with FWS-SAT for data on wetlands extent in and

[8]NOAA-C-CAP is coordinating its efforts on wetland quality with EPA's Environmental Monitoring and Assessment Program to determine the functional health of wetlands.

around salt marsh areas along the eastern Gulf Coast. The EPA-EMAP also monitors all the major upland ecosystem types, again in partnership with other agencies. The EPA-EMAP was begun in response to a 1988 recommendation by EPA's Science Advisory Board that EPA start a program to monitor ecological status and trends and develop innovative methods for anticipating emerging problems before they reach crisis proportions.

5. U.S. Geological Survey

The USGS collects and disseminates, in map and digital form, cartographic, hydrologic, and geologic information about wetlands.

The USGS produces and disseminates a variety of cartographic, image, and digital maps and data that are useful to Federal and State agencies involved in wetland research. The primary map series (for the most part, 7.5-minute quadrangles) is most often used, in both graphic and digital form. For project planning, intermediate-scale maps and data provide a regional perspective. Some Federal agencies are now increasing their support for even larger scale maps and data, primarily in an image format, including quarter-quadrangle orthophoto products.

The USGS also collects ground-water and surface-water information about the Nation's tidal and nontidal wetlands. "This information includes quantity, quality, and availability of ground water and surface water; ground-water and surface-water interactions (recharge-discharge); ground-water flow; and the basic surface-water characteristics of streams, rivers, lakes, and wetlands". "The USGS wetland-related activities include collection of information important for assessing and mitigating coastal wetland loss and modification, hydrologic data collection and interpretation, geographic information system (GIS) activities, identification of national trends in water quality and quantity, and process-oriented wetland research."[9]

The USGS also conducts research to provide the basic information needed to better understand "the geologic processes causing coastal erosion and

[9]The text in this paragraph was quoted from "Importance of Hydrologic Data for Interpreting Wetland Maps and Assessing Wetland Loss and Mitigation," by Virginia Carter, in "Federal Coastal Wetland Mapping Programs," p. 79.

deterioration of wetland environments". This research has been conducted in Louisiana in cooperation with FWS, the Louisiana Geological Survey, and other State agencies in Louisiana. (Williams and Salinger, 1989)

6. State of Maryland Water Resources Administration

The MD-WRA maintains an inventory of wetlands in the State to accomplish its regulatory and management functions. Since the enactment of the Tidal Wetlands Protection Act in 1970, the MD-WRA has conducted four distinct wetland mapping programs and has cooperated and shared costs with the FWS-NWI in the State. In 1971, the MD-WRA produced 2,200 uncorrected mylar photograph "maps" at a scale of 1:2,400 and annotated them with the tidal wetlands boundary as defined by State statute. These maps are official regulatory documents filed with each county clerk's office.

In 1986, an effort was begun to develop a digital wetlands map series to replace the 1971 Tidal Wetlands Boundary Maps. In 1987, this effort was stopped upon the advice of the Maryland attorney general regarding a public notice requirement for new maps, which State officials believed would have cost much more than the mapping effort. In April 1989, the Maryland General Assembly passed the Nontidal Wetlands Protection Act. This legislation requires Maryland to produce guidance maps showing the location of nontidal wetlands and wetlands of special state concern (WSSC) that have unique habitat value or contain rare, threatened, or endangered species.

The MD-WRA first produced a set of nontidal wetland guidance maps by compositing digital data from existing FWS-NWI maps to SPOT images. The agency is now supplementing these maps by photointerpreting 1:40,000-scale color infrared photographs and displaying the information on digital color orthophoto quarter-quadrangle maps (DOQQ) for the entire State. The MD-WRA expects to complete DOQQ's for the State by mid-1997. These maps are designed to be a base layer for many GIS mapping efforts, including an updated tidal and nontidal wetlands inventory.

C. Working Group Coordination Strategy

The sequentially ordered coordination strategy being implemented by the working group for the FGDC Wetlands Subcommittee addresses various issues relating to the coordination of wetland data collected by the Federal and State governments and other organizations. The strategy is sequential so that information gained from the completion of earlier tasks can be assimilated by later tasks. In addition, issues that are relatively simple and easy to resolve are dealt with early so that the benefits from any improvements can be incorporated into wetland data collection efforts as soon as possible.

Task 1 --

Integration of Terminology, Definitions, and Classification Systems

II. Task 1—Integration of Terminology, Definitions, and Classification Systems[10]

A. Overview and Background

Task 1 calls for government organizations to work together to ensure that terminology, definitions, and classification systems in their reports are consistent to the highest degree possible. Remaining differences in terminology should be documented and explained to avoid misinterpretation.

Since 1980, the FWS has used the Cowardin and others (1979) classification system[11] for all NWI wetland mapping and wetland data base development, including the collection and organization of data for wetland status and trends.[12] This classification system describes ecological units having certain common natural attributes, arranges these units in a system that aids resource management decisions, furnishes units for inventory and mapping, and provides uniformity in wetlands concepts and terminology throughout the United States.

The Cowardin and others classification system defines the limits of wetlands according to ecological characteristics and not according to administrative or regulatory programs. In general terms, wetlands are defined as lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.

[10]The information contained in this section on task 1 is derived from the original unpublished report describing the working group's findings in September 1992.

[11]The Cowardin et al. classification system is documented in "Classification of Wetlands and Deepwater Habitats of the United States," by Lewis M. Cowardin, Virginia Carter, Francis C. Golet, and Edward T. LaRoe, U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., FWS/OBS-79/31, December 1979. Much of the information contained in this section relating to the Cowardin et al. system is derived from this publication.

[12]NWI-SAT also describes upland land use categories. A modification of the Anderson and others (1976) system is used to include urban areas, rural development, forested plantations (silvaculture), agriculture, and other uplands.

The Cowardin and others system presents a method for grouping ecologically similar wetlands. The system is hierarchical, with wetlands divided among five major ecological systems at the broadest level—Marine, Estuarine, Riverine, Lacustrine, and Palustrine. Each system is further subdivided by subsystems that reflect hydrologic conditions, such as Subtidal versus Intertidal in the Marine and Estuarine systems.

Below subsystem is the class level, which describes the appearance of the wetland in terms of vegetation (for example, Emergent, Aquatic Bed, Forested) or substrate if vegetation is inconspicuous or absent (for example, Unconsolidated Shore, Rocky Shore, Streambed). Each class is further divided into subclasses. The classification system also includes modifiers to describe hydrology (water regime) and water chemistry (pH, salinity, and halinity), and special modifiers relating to human activities (for example, impounded, partly drained, farmed, artificial).

Below the class level, the classification system is open-ended. The dominance type is the taxonomic category subordinate to subclass. Dominance types are determined on the basis of dominant plant species, dominant sedentary or sessile animal species, or dominant plant and animal species. The system provides examples of many possible dominance types.

The Cowardin and others classification system replaced the first classification system developed by the FWS. This system, published in "Wetlands of the United States" (1956) and known as FWS Circular 39, was based on a 1954 FWS nationwide wetlands survey that focused on important waterfowl wetlands. The survey covered approximately 40 percent of the lower 48 States. The FWS discontinued the use of Circular 39 because of improvements in the newer Cowardin and others wetland classification system.

The NRCS has used more than one wetland classification system. The NRCS-WI uses a system that was developed to be consistent with the FSA's definition of a wetland: *"Lands that have a predominance of hydric soils that are inundated or saturated at a frequency and duration to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation* *typically adapted to life in saturated soil conditions.*"[13] This definition contains the three wetland parameters (soils, hydrology, and vegetation) that have been used to identify wetlands under Section 404 of the Clean Water Act, and by the FWS-NWI. (Teels, 1990).

The NRCS-WI classifies areas with the following designations intended primarily for the FSA: (1) prior conversion—converted before December 23, 1985, but not abandoned;[14] (2) farmed wetland—still meets the wetland criteria, including seasonally ponded wetlands, seasonally flooded wetlands, potholes, and playas; (3) wetland—includes natural conditions and abandoned wetlands; (4) commenced conversion; (5) third party—conversion by third party; (6) converted wetland—converted after December 23, 1985; (7) minimal effect; and (8) artificial wetland (any wetland existing due to human activities)—including irrigation-induced wetland.[15]

The NRCS used both the classification system documented in FWS Circular 39 and the Cowardin and others system for the 1982 NRI. The NRCS used the Circular 39 classification system for the 1977 and the 1987 NRI's and for the 1991 special NRI wetlands report.

NOAA-C-CAP uses a system that integrates the Cowardin and others wetlands classification system and the Anderson and others (1976) land use and land cover classification system. The integrated system was developed by NOAA in concert with the FWS, EPA, and the USGS.

B. Results

The FWS, the NRCS, NOAA, EPA, and the USGS have agreed to use the Cowardin and others wetland classification system or a system that is compatible with the Cowardin and others system. Using the same classification

[13]The FWS-NWI also uses this definition, but does not restrict its efforts to only vegetated wetlands.

[14]The NRCS defines abandoned areas to be areas that have not been cropped for at least 2 out of the last 5 consecutive years.

[15]Designations 4, 5, 6, and 7 can be made only after a field investigation.

system, or a compatible system, should ensure that government organizations classify areas with the same land condition consistently.

The 1992 NRI, released during 1994, also classifies land areas using the NRCS-WI system that is based on FSA (Swampbuster) requirements. The 1992 NRI includes a review and update of the 1982 determinations using the Cowardin and others classification. For the 1992 NRI, the NRCS uses the Cowardin and others wetland classification system to the system level.

The class level describes the general appearance of the habitat in terms of either the dominant life form of the vegetation or the composition of the substrate. These are features that can be easily recognized without detailed environmental measurements. The major life forms (trees, shrubs, emergents, mosses/lichens, and aquatic vegetation), are used to define classes because (1) they are relatively easy to distinguish and extensive biological knowledge is not required to distinguish between various life forms; (2) these life forms are easily recognizable on a great variety of remote sensing products; (3) they do not change distribution rapidly; and (4) they have traditionally been used as criteria for the classification of wetlands.

The NRCS-WI information is documented on various maps, photographs, and soil survey sheets. There is no national standard scale or map on which the inventory is produced. The NRCS expects to eventually incorporate the FSA wetland determinations into a standardized county map system and a digital county data base that will be adopted by all USDA agencies.

Some jurisdictional wetlands under the Swampbuster provision of the FSA (primarily farmed wetlands) are not identified in all regions of the Nation on FWS-NWI maps. These wetlands, however, are included within the FWS-NWI status and trends statistical estimates.[16]

[16]The FWS-NWI does not map areas as wetlands on NWI maps if they are classified by the NRCS as Prime Farmland. This policy was implemented in the 1970's to avoid confusion between the NRCS and FWS classifications.

The Coastal Wetlands Planning and Restoration Act of 1990 requires the FWS-NWI to update and digitize wetland maps of Texas. The FWS-NWI is adding farmed wetlands to these updated maps. The FWS plans to compare these maps with the NRCS-WI.

It should be noted that government organizations continue to disagree on how best to incorporate wetlands into land classification systems. In an ongoing FGDC investigation into developing national standards for wetland classification, vegetation classification, and land cover classification, the FWS, NOAA, EPA, the USGS, and the NRCS place different emphases on wetlands. The FWS, NOAA, EPA, and the USGS believe wetlands should appear in land cover classifications as a discrete category; the NRCS, on the other hand, contends that wetlands are a condition of the land, rather than a land cover, and should not appear in a land cover classification as a discrete category.

In the procedures to be enacted for the 1992 NRI, the NRCS will increase the emphasis on cover types and move away from the strictly land use category. However, the NRCS will keep wetland, earth cover, and land use classifications separate. The NRCS's rationale for separating these classifications is that crop land or commercial forest can also be wetland.

The FGDC is considering an approach for implementing a land use/land cover classification effort. The FGDC Wetlands Subcommittee will work with the FGDC Coordination Group on this land use versus land cover issue. The outcome of this issue will not affect the delineation of wetlands, because all agencies will be using the Cowardin and others classification (or Cowardin compatible) in their inventories; however, it could result in differences in classifying what caused a loss of wetland.[17]

In the past, differences in interpretation of cover types have affected the amount and type of wetlands identified. One area where the FWS and the NRCS have disagreed concerns the conversion of wetland to open water. The FWS-SAT considers the change of a vegetated wetland to an open-water area to be a conversion of wetland type if the open-water area is less than 20 acres.[18] If the open-water area is greater than 20 acres, it is considered to be a loss of

[17]Comparisons of upland land use definitions are not being made at this time.

[18]The FWS selected a threshold of 20 acres for ecological reasons. The FWS-SAT also reports that "This is in keeping with the Cowardin et al. classification system. FWS-SAT makes every effort to record only actual type change by attempting to determine the "average state" of the wetland. For example, consideration is given as to whether or not available aerial photography was produced during an unusually dry year or season."

wetland and a gain of deepwater habitat. The NRCS-NRI and NRCS-WI depend upon on site evaluations to determine whether the open-water area continues to meet wetland criteria. If on site personnel determine that the area retains wetland characteristics, no conversion is recorded; if, however, they determine that the area no longer meets wetland criteria, then the area is considered to have been converted to open water. With the NRCS using the Cowardin and others system for the 1992 NRI, these differences should be resolved.[19]

The working group decided that upland classification was beyond the scope of this effort and did not consider upland classification similarities and differences.

[19]The NRCS notes that NRCS-WI "does not consider changes in cover type to be a conversion *unless* the manipulation results in an area that can be cropped. (If the action makes possible the production of an agricultural commodity on a wetland site, that is considered a wetland conversion. In most cases, covering a wetland with open water would not make the area suitable for agricultural commodity production, hence no conversion from the FSA/FACTA standpoint.)"

Task 2 --

Coordination of Data Collection Processes and Reports

III. Task 2—Coordination of Data Collection Processes and Reports[20]

A. Overview

Task 2 calls for the coordination of government wetlands data collection processes and reporting procedures. The presentation of data in similar formats will facilitate comparisons among wetland reports of different organizations. Coordination of reporting procedures and scheduling will ensure that users of these data receive the most reliable and up-to-date information. Coordination will also allow the efficient exchange of data and results among organizations.

B. Results

The working group proposes two primary steps to improve the coordination of data collection processes and reports. The first step involves developing a method to compare the data sets included in various government wetland publications. The second step involves developing a National Wetlands Data System (NWDS), which will provide access to the various wetland map data sets from different government agencies.

To facilitate comparisons among various government wetland reports, the FWS, the NRCS, NOAA, and EPA will include a crosswalk in future reports on wetlands. The crosswalk will explain the relationship among wetland data sets used and described in their respective reports and the various other wetland data sets produced by other government agencies. The structure for this crosswalk will be developed during the completion of task 3.

The working group also recommends that the various wetland digital data sets be made available through a single unified data system that also includes maps. The specific characteristics and the design of the data system will be developed during task 4. The intent of this spatial data system will be to

[20]The information contained in this section on task 2 is derived from the original unpublished report describing the working group's findings in September 1992.

present to the Nation an integrated set of wetland data (produced by various government organizations), with consistent protocols, that meets national needs.

To further this coordination effort, the FWS-NWI and NOAA-C-CAP have agreed "to coordinate their inventory and monitoring programs that utilize remote sensing technology to examine the distribution and abundance of coastal habitats and the rate of their loss or gain over time." The FWS-NWI and EPA-EMAP have signed a similar coordination document. Since October 1992, EPA has provided a full-time liaison to the FWS, collocated with FWS-NWI staff, to assist in the integration of EMAP qualitative data with NWI quantitative data; specifically, integrating the wetlands component of EPA-EMAP with the NWI-SAT. This liaison from EPA joined the USGS liaison already working directly with the FWS.

Task 3A --

Consistency of Data

IV. Task 3A—Consistency of Data

A. Introduction

Task 3 calls for government organizations that collect wetland data for inventory and for status and trends to compare and reconcile their respective data and results. This task also calls for the government organizations to develop reports that include crosswalks and explanations concerning other government wetland data and results.

The purpose of task 3A is to identify the level of consistency among wetland data sets collected by various government organizations and to determine possible causes of inconsistencies. This evaluation will help government organizations collecting wetland data reconcile their data sets and develop improved methods.

This report describes the results of a pilot data comparison study that the working group has completed in Wicomico County, Md. The working group eventually plans to evaluate wetland data from up to 10 counties with varying wetland density and complexity. The 10 counties tentatively chosen for study were selected to ensure diversity in wetland, geographic, and other characteristics, as shown below:

- geographic distribution within the contiguous States;
- variability in wetland types and density;
- differences in land use;
- conflicts in land use;
- variability in amounts of urban and rural areas;
- representation of coastal and inland areas;
- large differences in Federal land ownership; and
- large differences between wetland acreage estimates from the FWS-NWI and NRCS-NRI.

The 10 counties tentatively chosen for analysis are:

Wicomico, Md.	Dade, Fla.
Logan, N. Dak.	Washington, N.C.
Terrebonne, La.	Camden, N.C.
Meade, Kans.	Penobscot, Maine
Yazoo, Miss.	Tulare, Calif.

The working group started a pilot study to better understand the issues and problems associated with the data comparison task. Wicomico County, Md., was selected as the pilot because (1) wetland data and other spatial data in digital form are available from the various government organizations; (2) the county's proximity to the Washington, D.C., area facilitates field analysis where necessary; and (3) the county has an abundance of forested wetlands, which are generally recognized as the most difficult wetland type to map.

B. Wicomico County, Maryland, Pilot Study

1. Description of Wicomico County, Maryland[21]

Wicomico County is located on Maryland's eastern shore (see fig. 1). Wicomico County's population in 1990 was 74,339, a 17.9 percent increase since 1980.[22] Salisbury is the county seat and the focal point of the county. The two major highways, U.S. Routes 50 and 13, intersect in Salisbury near the Wicomico River. This makes Salisbury the hub of bulk transportation within the county.

Wicomico County is situated on the Atlantic Coastal Plain. Lithologically, this part of the Coastal Plain is composed of marine units of varying thicknesses. Clay, sand, and shells are the major deposits.

[21]This description of Wicomico County, Md., is derived from an unpublished paper by Tera Paul, U.S. Geological Survey.

[22]1990 Census of Population and Housing

Wicomico County, Maryland

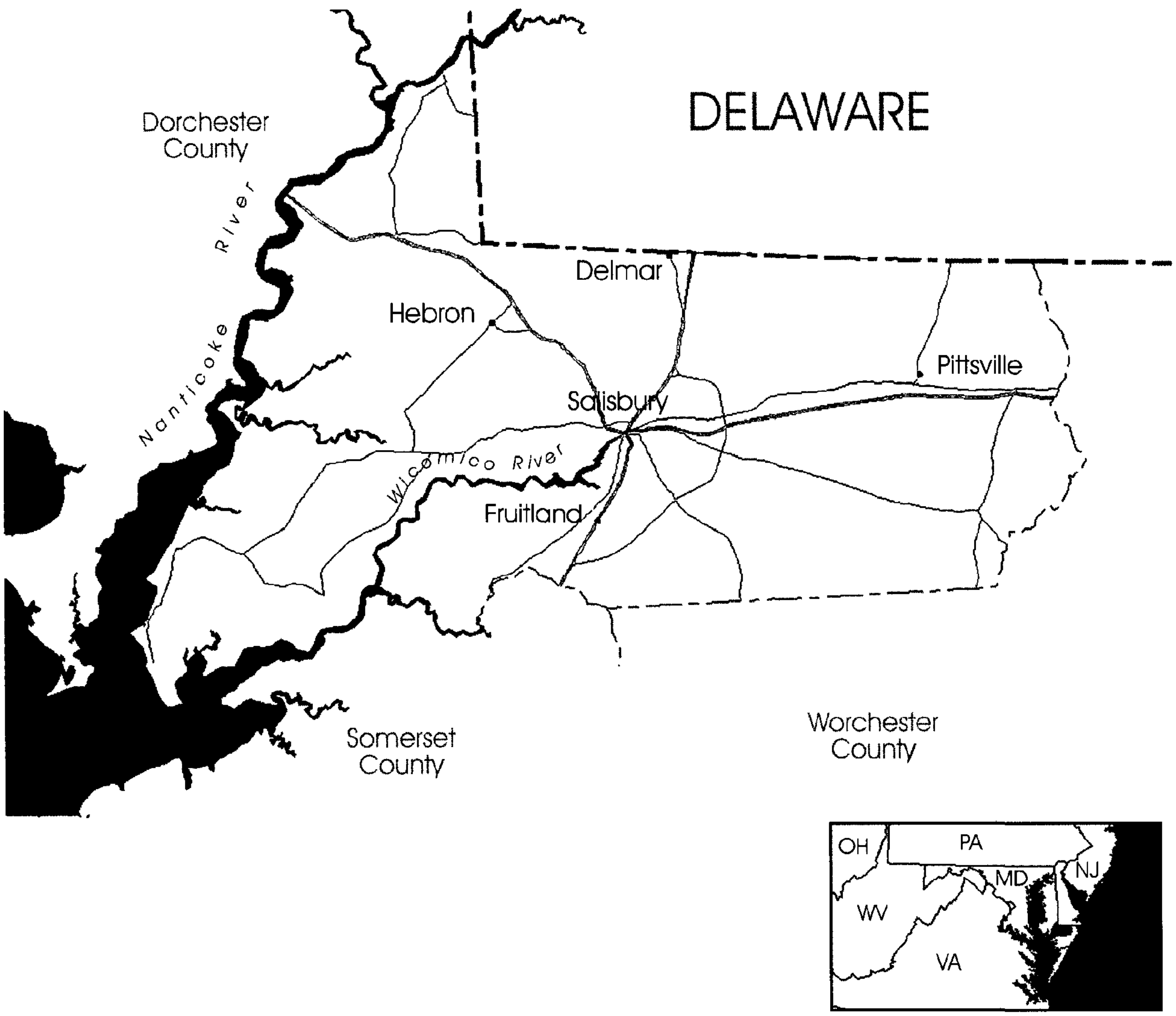

Figure 1. Wicomico County, Maryland is the site of the pilot wetland data comparison.

Scale 1:370,000

Characteristically, the surface is of low elevation, usually between 0 and 25 feet. The low elevation and the broad smoothness of the region cause the streams to have a gentle gradient and the stream incision is minimal. The amount of stream incision directly affects the level of the water table; thus, the water table is high throughout the county. The low elevation and smoothness of the land surface combined with a gentle stream gradient and high water table result in a well-developed floodplain and extensive areas of wetlands. Small changes in elevation, microtopography, or parent material will determine whether a given site is wetland or upland.

The soils strongly reflect the parent materials and drainage conditions and have developed on sand deposits. Large areas of land are poorly drained, and more than 80 percent of agricultural revenue is earned from poultry and livestock.[23]

2. Methodology

The comparison of diverse wetland data sets from government organizations involves (1) collecting relevant data; (2) assembling the data into a GIS, and (3) analyzing the data.

a. Data

Wetland data for the pilot study in Wicomico County, Md., were assembled from the FWS-NWI, FWS-SAT, NRCS-WI, NRCS-NRI, NOAA-C-CAP, EPA-EMAP, USGS Land Use Data Analysis Program (USGS-LUDA), and the MD-WRA. For reasons explained later in the report, the EPA and USGS concluded that it was not appropriate to compare the wetland identification from the EMAP and LUDA data sets with the other data. The data sources and related information are summarized in table 1.

The wetland data vary in several ways in addition to the different classification systems described earlier in this report. Wetland delineations are made from manual interpretation of high-altitude aerial photographs, from computer-assisted analysis of satellite data at different scales and times, and

[23]1988 County and City Data Book

Table 1. Wicomico County, Maryland, Pilot Study Data Sets

[The source dates for NRCS-WI are soil survey (published in 1970), color infrared (March 1982), ASCS color slides (1987-88), and ASCS panchromatic photographs (1988-89)]

Name	Source Date	Size (kilobytes)	Data Type	Coding Scheme	Date Received
USGS-LUDA	1973	467	vector	Anderson	9/10/92
NRCS-NRI	1982	611	point-(two files)	wet/not wet and Cowardin-like	11/18/92
FWS-NWI	1981-82	5,547	vector	Cowardin	9/9/92
FWS-SAT	1988	256	vector	Cowardin and Anderson (modified)	9/9/92
NRCS-WI	(see note)	9,495	vector (converted from paper)	wet/not wet	10/19/92
NOAA-C-CAP	1988-89	21,076	raster	Cowardin and Anderson (modified)	10/14/92
EPA-EMAP		11,992	raster	TM	11/19/92
MD-WRA	1988-89	4,484	vector	Cowardin	9/15/92
Color DOQQ (MD-WRA)	4/88 & 4/89	85,000 per quarter quad	raster	false-color images	9/15/92

from varying numbers of field visits. The data include both raster and vector types and are both point and polygon in form.

The FWS-NWI, FWS-SAT, and MD-WRA rely primarily on the interpretation of color infrared (CIR), leaf-off aerial photographs to classify wetlands. The FWS-NWI used 1:58,000-scale CIR aerial photographs collected in 1981-1982, the FWS-SAT used 1:40,000-scale CIR aerial photographs collected during 1988, and the MD-WRA used CIR aerial photographs collected during 1988-1989.[24] Both the FWS and MD-WRA use stereoscopic techniques to interpret aerial photographs.[25]

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[24]It takes approximately 3 aerial photographs at the scale of 1:58,000 or 10 aerial photographs at the scale of 1:40,000 to provide stereoscopic coverage for the area included within a 7.5-minute quadrangle. Generally, wetland delineations are more accurate at larger scales.

[25]The FWS reported to the working group that it has updated four of the 1:24,000-scale quadrangles in Wicomico County since this data comparison began. According to FWS: *"The FWS updated four 1:24,000-scale quadrangles within Wicomico County in support of Phase II of the Chesapeake Bay Watershed Trend Analysis Project. Field work was conducted from January 20 to 22, 1993 within the Pittsville, Wango , Delmar, and Salisbury quadrangles. NWI maps covering these four quadrangles were originally produced from 1:58,000-scale Color Infrared (CIR) aerial photographs flown in March of 1982; the updated maps are based upon photointerpretation of 1:40,000-scale CIR aerial photography taken in April of 1989. The updating of these NWI maps resulted in significantly improved wetland delineation and classification.*

"During the Trend Analysis Project, it became evident that the original wetlands mapping was too conservative. This was due primarily to a difference in resolution and a bluish emulsion which masked drier wetland signatures on the 1982 photography. Subtle signatures indicating saturated soil conditions and areas of temporary flooding (water regimes on the drier end of the wetland hydrologic spectrum), particularly those hydric soils under a dense canopy of evergreen and deciduous (or mixed) forest, were not apparent (or were masked) on the 1982 photography. These areas were classified as upland instead of the more correct designation of either evergreen forested wetland (PFO4) or deciduous forested wetland (PFO1) with water regimes being either saturated (B), temporarily flooded (A), or even seasonally flooded (C or E). Comparison of the original NWI maps with the Soil Conservation Service's Soil Surveys indicated extensive areas of hydric soil map units whose polygons often extended well beyond the delineated boundaries on the NWI maps. Updating also brought the NWI maps into close conformity with wetlands mapping conducted by the State of Maryland's Water Resources Administration, which used the same wetlands classification system as NWI. The increased resolution of the newer photography enabled interpreters to identify hydric soils in topographic depressions within cultivated fields, thus the delineation of farmed wetlands, as defined by Cowardin et al., was added to the maps.

The NRCS-WI data were developed using soil survey data published in 1970 as the base (Hall, 1970). In addition to using the soils data, the NRCS-WI made wetland delineations in Wicomico County using 1:15,840-scale National High Altitude Photography (NHAP) CIR aerial photographs (flight date: March 28, 1982), 1:7,920-scale National Aerial Photography Program (NAPP) black-and-white infrared photographs (flight year:1989), and color slides (flight years: 1987 and 1988). The NRCS-WI maps were created as a guide for making wetland determinations for the FSA, and, as a result, were designed to overstate rather than understate wetland acreage.

The multidisciplinary teams that collected NRCS-NRI data in Wicomico County in 1982 made delineations that were based on selected field examinations. Unlike the other wetland data sets, the NRCS-NRI data are point data rather than areal data. As was described earlier in this report, these point data are not mapped but are instead used to develop statistical information. The NOAA-C-CAP data were derived from Landsat Thematic Mapper 1988-1989 images with a spatial resolution of 30 meters. The NOAA-C-CAP's data are in raster format, in contrast to the vector data associated with the FWS-NWI, FWS-SAT, MD-WRA, and NRCS-WI.

The EPA determined that it was not appropriate to compare the EMAP data in Wicomico County with the other data because the EMAP data *"were not generated to map wetlands specifically or to provide wetlands status and trends information, but rather to provide a general characterization of land cover and land use patterns. For this reason, these data are not being compared to those of the other programs, which are specifically oriented toward wetlands mapping... This project was designed to incorporate NWI airphoto-derived wetlands information along with the Landsat TM [Thematic Mapper] interpretations, but funding limitations have thus far prevented this from being completed...the project was able to digitize hundreds of NWI*

"The majority of the areas changed were boundary extensions of existing polygons, delineation of discrete units within existing wetland polygons, or addition of previously undetected wetlands. Most classification changes and additions were in the forested wetland (both deciduous and evergreen) and scrub-shrub classes. Seasonally flooded emergent areas were added as inclusions within existing polygons and along water courses. Most changes were associated with the Fallsington, Pocomoke, and Elkton soil series."

quadrangles that were previously available only as hardcopy maps...The EMAP Wetlands program relies on the National Wetlands Inventory program in two main areas: use of NWI maps as sources for choosing sampling sites for monitoring wetlands condition, and reliance on NWI status and trends program to provide information on wetland extent."[26]

The USGS reported to the working group that "*For several reasons, the LUDA data are not appropriate for use in the wetlands comparison study.*

"First, the data collected are at a scale too gross for acreage comparisons and for comparing conventions for identifying wetland areas. The fact that there are only two categories of wetlands identified imply that the classification system used was too general to identify wetlands to the degree that NWI and NRI identify them.

"Second, it was the intention of the LUDA data managers to provide a foundation to State and local organizations and to other Federal agencies to expand on the classification system and the land use and land cover delineations. To use the wetland delineations from the LUDA Program would be similar to comparing generalized data to site specific data.

"Third, although the primary data source was the same as used by the NWI, the age of the source materials is very different. The conversion of wetlands to a higher order use would adversely affect the comparison of both data sets.

"Fourth, positional accuracy was not as important as relational accuracy as borne out by the 1:250,000-scale compilation base. Although the data were recorded at the 1:125,000-scale, the accuracy of the base was no better than 1:250,000. This is a major difference from the 1:24,000-scale used by NWI. For these reasons, the comparison of LUDA wetland acreage and delineations with the NWI data would not provide meaningful results."[27]

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[26]Communication from Doug Norton, Office of Water, Environmental Protection Agency, Washington, D.C., April 21, 1993

[27]Communication from Michael Chambers, Requirements Officer, National Mapping Division, USGS, Reston, Va., June 1993.

b. Assembly of the Data into a GIS

The comparison of the various wetland data sets involves the use of geographically referenced digital data in a GIS environment. At the request of the Chair, FGDC Wetlands Subcommittee, the USGS National Mapping Division is assisting the working group in implementing the analysis through the use of GIS technology.

The USGS Mapping Applications Center (USGS-MAC) has been providing analytical and technical support to the working group in the pilot study area by (1) developing a framework for analysis using GIS technology, (2) assembling the digital data from the various government organizations, (3) conducting comparisons to determine where the various wetland data sets are consistent and inconsistent, and (4) providing plots, other viewing materials, and tabular data so that the working group can examine the data and can develop explanations for data patterns. In addition, USGS-MAC completely digitized and tagged the NRCS-WI data from photocopied pages.

Some of the complexity of assembling the data in a GIS can be seen from the varying sizes of the data bases. Table 1 indicates that the data bases range in size from 611 kilobytes (NRCS-NRI) to 85,000 kilobytes per quarter quadrangle (the color digital orthophotoquad from MD-WRA). The USGS-MAC translated and placed the digital data together so that these data could be interpreted and analyzed on a single computer workstation. All of the data were scaled and projected so that cartographic differences could be normalized. Positional differences that are observed in the analysis are therefore inherent in the original files.

The USGS-MAC wrote computer programs to facilitate spatial analysis of the digital data. For instance, as was described earlier in this report, the data sets use different wetland classification systems. Programs were developed to sort codes into individual fields so that comparisons by specific attribute could be made automatically.

Programs also were written to allow the working group to make graphic and tabular comparisons and evaluations of the data. The various overlays can be viewed simultaneously and drawn on the screen using colors and patterns according to specific wetland attributes. In addition, the distances between features and the sizes of areas can be measured easily. Color electrostatic plots of each data set were made at the 1:100,000 and the 1:24,000 scales.

c. Analysis

The analysis in the Wicomico County pilot study was designed to provide information on two primary issues: (1) the level of consistency among the various government wetland data sets and (2) the relative strengths and weaknesses among the data sets. The analysis was designed to provide general comparative information and to identify possible patterns among the data sets; its purpose is not to determine which data sets are more correct or to test statistical hypotheses.

To determine the level of consistency among the various data sets, the working group compared the total acreage in the Wicomico County study area that each data set classifies as wetland. This comparison was broadened to evaluate the acreage that each data set classifies within various systems or subcategories of wetlands. Although acreage comparisons are important for evaluating national wetland acreage projections, this type of comparison by itself is an inadequate indicator of consistency. Even though total acreage classified as wetlands may be similar, different areas within the study area may be classified as wetlands in the various data sets. Thus, although the acreage estimates may be close, the actual locations of areas delineated as wetlands may be inconsistent.

To resolve this problem, the working group developed and examined a series of maps showing areas of agreement and disagreement in wetland designation among the various data sets. The maps were plotted at both the 1:24,000 scale and the 1:100,000 scale. Although the maps are useful to evaluate specific spatial issues and to identify general patterns, tabular acreage data are required to make a more complete comparison among the data sets. To obtain these data, a series of matrices was developed to compare areas of agreement and disagreement. These matrices are divided by system or type of wetland to facilitate comparisons in agreement between data sets.

Tests to determine the relative strengths and weaknesses of government wetland data sets are difficult because there is no standard of correct wetland classification with which to compare the various wetland data sets. That is, if there is an inconsistency among the data sets in wetland classification, data do not exist to resolve the inconsistency.

To obtain independent information on whether a site was actually a wetland or an upland, field data in the Wicomico County study area were collected and compared with the wetland classifications from the various government data sets. Two tests were conducted to develop information on the relative strengths and weaknesses of the government wetland data sets. The first test involved examining 130 points in the field in the Wicomico County study area to determine whether wetlands or uplands existed at the points. The working group selected the points because of inconsistencies in wetland classification among the data sets at the points and to resolve questions relating to wetland identification. An independent contractor with expertise in wetlands identification collected the data at the 130 points in the field in May and June 1993. The contractor used the data form for Routine Wetland Determination from the 1987 Army Corps of Engineers Wetlands Delineation Manual and a supplemental field data form used by the MD-WRA for an earlier Wetlands Mapping Ground Truth project. In addition to making a wetland determination at the point, the contractor reported on the vegetation, hydrology, and soils, as well as on whether there was evidence of significant land use/land cover change within the last 10 years and whether the site was within 50 meters of a wetland boundary.

Because many of the points selected in the first test were found to be near wetland boundaries, a second test was designed to examine a series of points along transects so that the impact of boundary changes could be assessed.[28] The working group selected the transects on the basis of

[28]Wetlands are a transition between aquatic conditions and mesophytic (well-balanced moisture) or xerophytic (dry) conditions. This transition occurs as a continuum or gradation from one condition into another; wetlands are not always small isolated pockets. Transect sampling enables the investigator to obtain data over a broad spectrum of conditions as opposed to single, isolated data representing only a point on the ground. Within this gradation may be found areas of mixed wetlands and nonwetlands, units so small that they

inconsistencies among the wetland data sets or to study other issues that they had identified. In July 1993, a field team from the working group collected data on whether points on the transects were wetlands, uplands, or transitional, as well as data on soils, vegetation, and hydrology.

d. Previous Studies

In 1992, the FGDC Wetlands Subcommittee, at the request of the President's Domestic Policy Council's Wetlands Task Force, wrote a report evaluating the application of satellite data for mapping and monitoring wetlands (Wetlands Subcommittee, 1992). The report was based on discussions with technical experts representing various organizations from government, academia, and environmental groups.

The Wetlands Subcommittee concluded that "The detail and reliability of information derived from satellite data have steadily improved." "For some regions," the report states, "satellite remote sensing may be the most cost-effective means for conducting reconnaissance wetland surveys." However, the report states that "satellite data cannot match the accuracy of areal extent, classification detail, or reliability that can be extracted from conventional aerial photography using manual photo-interpretation techniques, such as those used by the U.S. Fish and Wildlife Service's (FWS) National Wetlands Inventory (NWI) Project."

The report identified several limitations in using satellite data for monitoring wetlands and uplands. These limitations range from an "inability to classify more than a limited number of wetland classes" to an "inability to reliably and routinely detect forested wetlands and scrub-shrub wetlands." The report concludes that using satellite data causes "underestimations of the

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cannot be delineated individually.

A transect enables the investigator to get a feel for the lay of the land and make a determination of the area as a whole. Most wetlands are a heterogeneous area; they are a mixture of several wetland types or wetlands and nonwetlands. The transect method of delineation enables the investigator to locate the wetland boundaries more efficiently and classify the area as a whole. Point sampling in heterogeneous areas may result in the investigator inadvertently picking at random a site that is not characteristic of the entire area or introducing a bias to the sampling procedure by focusing on the wetter sites.

acreage of individual wetlands; the amount of underestimation is not consistent."

The conclusions from the report remain controversial within the Wetland Data Coordination Working Group and the FGDC Wetlands Subcommittee. They are described here because they are part of the publicly available literature on this subject.

In July 1991, a workshop held in the area around Salisbury, Maryland, evaluated data from NOAA-C-CAP and FWS-NWI (Salisbury State University and others, 1991). Separate teams evaluated data in the field in seven USGS 7.5- minute quadrangles. "Each group was asked to determine the degree to which the land cover polygons had been correctly classified for each of the two TM [Thematic Mapper] dates (1984, 1988) and by NWI for maps based on photography taken during March, 1982 and April, 1981." Sites visited were either classified as random sites (selected randomly) or selected sites (sites that were of particular interest or curiosity).

The study team found that the "accuracy of polygon classification in the preliminary C-CAP product is very high overall with many of the errors subject to straightforward identification and correction. Accuracy ranged from 63 percent to 97 percent by quadrangle for randomly selected sites, with six of the seven quadrangles having a classification accuracy of 87 percent or better. On the other hand, selected sites generally were misclassified and the classification accuracy for these polygons was 15 percent to 50 percent." The workshop reported that the "NWI products generally appeared to be very accurate in both spatial resolution and classification." It also reported that "problems were noted in differentiation of forested wetlands and forests. Coastwatch tended to identify these sites as forest and NWI tended to correctly identify these areas."

The NOAA-C-CAP data used in the current FGDC analysis described in this report were revised after the 1991 workshop. According to NOAA, the C-CAP data evaluated in the 1991 workshop were part of a preliminary data set. NOAA reports that the entire data set was reclassified "based on observations during the workshop and C-CAP's own field verification efforts..."

In May 1992, the FWS-NWI published a paper on "Comparison of Four Scales of Color Infrared Photography for Wetland Mapping in Maryland" (National Wetlands Inventory, 1992). The objectives of the study were "(1) to compare four scales of color infrared photographs for identifying wetlands and (2) to determine differences in the effort required to interpret the photos and produce wetland maps from each photo scale." The scales evaluated were 1:12,000, 1:24,000, 1:36,000, and 1:58,000, and the test area was the Millington Quadrangle on the eastern shore of Maryland. Because larger scales provide more detail, it was expected that the 1:12,000-scale photographs "would allow for the detection and mapping of additional smaller individual wetlands as well as more detail within larger wetlands than could be accomplished at other scales." In fact, photointerpretation from larger scale photographs did result in more polygons and acreage being classified as wetlands. The greatest difference between the different scale photographs was for polygons between 0.1 and 0.5 acres, which "accounted for 96.8 percent of the difference in number of wetlands and 75.8 percent of the differences in wetland acreage of those wetlands between 1:12K and 1:24K photos."

The study team concluded that "the 1:12 K photos produced the greatest acreage of wetlands compared to other [large] scales (1:36K and [1:24K]), chiefly because of the ability to delineate small individual wetlands (less than 0.5 acres in size)." In addition, "forested wetlands accounted for the main acreage differences in unique polygons (small individual wetlands) and in refinements of wetland boundaries, with the temporarily flooded type having the greatest impact." "The level of effort (and subsequent costs) increased dramatically with increasing photo scale due to the number of photos and to the level of detail that can be observed and delineated. It took 6.2 times as much effort to produce a wetland map from the 1:12K photos as it did from the 1:58K, 3.6 as long to produce a wetland map from the 1:36K versus the 1:58K."

3. Results

a. Introduction

Among the four data sets with full-coverage mapping programs, FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI, there is agreement that the majority of land in the Wicomico County study area is upland.[29] However, there is significant disagreement among the data sets both on the amount of acreage classified as wetlands and on the location of the wetlands. Within this disagreement among the data sets is a pattern in which NRCS-WI and NOAA-C-CAP appear to exhibit a greater tendency to classify an area as wetland than do the FWS-NWI and MD-WRA.

Most wetlands in the Wicomico County study area are palustrine; in turn, most palustrine wetlands in the study area are forested. Areas that are classified by at least one data set as palustrine forested wetlands account for a large proportion of the disagreement between the data sets. It appears that this is true both because of the fact that most wetlands in the study area are palustrine forested and because of the difficulties associated with identifying wetlands in forested areas using remote sensing techniques.[30]

b. Wetlands Acreage

The FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI all agree that more than 60 percent of the Wicomico County study area is upland. It can be seen from table 2, however, that the data sets vary widely in their

[29]The NRCS-WI does not use the term upland; rather, it classifies the area as "not wetland."

[30]See "Use of High-Altitude Aerial Photography for Inventorying Forested Wetlands in the United States," by Ralph W. Tiner, Jr. in "Forest Ecology and Management," 33/34 (1990), p. 593-604. Also, see Salisbury State University (1991).

Tiner (1990) concludes that "Evergreen forested wetlands, temporarily flooded deciduous forested wetlands, forested wetlands in rainforest regions, and hydrologically altered forested wetlands are among the most difficult wetlands to photo-interpret." According to FWS-NWI and MD-WRA data, approximately 40 percent of the palustrine forested wetlands are temporarily flooded deciduous wetlands and an additional approximately 20 percent are evergreen forested wetlands. Thus, over half of the palustrine wetlands in the study area are in the most difficult to photointerpret subclasses that Tiner identifies.

assessment of the mix of wetlands and uplands in the study area.[31] NRCS-WI, for instance, classifies almost four times as much acreage as wetlands as does FWS-NWI.

This large apparent disagreement between NRCS-WI and FWS-NWI is explained partly by the different mission responsibilities of the two data sets and the techniques used to classify wetlands. The data collected for NRCS-WI are required for regulatory purposes under the Food Security Act of 1985, and as a result, it is NRCS's intent to identify potential forested wetlands during the inventory. On site wetland determinations are made if a landowner wants to convert a forested area that has been classified as wetland. In Wicomico County, NRCS-WI classifies areas as wetlands if the area is forested and is within a hydric soil mapping unit, according to the published soil survey.[32] The mission of FWS-NWI, on the other hand, is to map wetland areas on a scientific basis rather than for direct regulatory purposes. As a result, FWS-

[31]The FWS-SAT and NRCS-NRI collect data for only a sample of the study area; FWS-SAT has data for less than 2 percent of the study area, and NRCS-NRI has data for 258 points within the study area. The FWS-SAT classifies approximately 74 percent of the 2,591 acres included within its sample in the study area as uplands and 26 percent as wetlands. The NRCS-NRI classifies approximately 71 percent of its points in the study area as uplands and 29 percent as wetlands.

[32]For more information on hydric soils, see "Hydric Soils of the United States," United States Department of Agriculture, Soil Conservation Service, Miscellaneous Publication Number 1491, June 1991.

The document defines a hydric soil as "a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part."

"Hydric soils are developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation. This list includes phases of soils that may or may not have been drained. Some series, designated as hydric, have phases that are not hydric depending on water table, flooding, and ponding characteristics."

The list of hydric soils includes "a number of agricultural and nonagricultural applications. These include assistance in land-use planning, conservation planning, and assessment of potential wildlife habitat. A combination of the hydric soil, hydrophytic vegetation, and hydrology criteria defines wetlands as described in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (Federal Interagency Committee for Wetland Delineation, 1989). Therefore, an area that meets the hydric soil criteria must also meet the hydrophytic vegetation and wetland hydrology criteria in order for it to be classified as a jurisdictional wetland."

Table 2. Distribution of Wetlands and Uplands (Acres)

[The FWS-NWI, FWS-SAT, and MD-WRA wetlands include palustrine, lacustrine, riverine, and estuarine. These wetland systems are divided into 52 classes, which are in turn divided into many subclasses. The NOAA-C-CAP wetlands include palustrine forest, mixed scrub/shrub, estuarine emergent wetland, water, palustrine emergent wetland, and tidal flats. The NRCS-WI wetlands include wet and farmed wet. The NOAA-C-CAP uplands include grassland, forest (deciduous, evergreen, mixed), cropland, developed land, and exposed land. The NRCS-WI uplands include nonwet and prior converted. It should be noted that the number of systems or classes used to determine wetland acreage for each data set does not imply the number of wetland types within each data set; for FWS-NWI, FWS-SAT, and MD-WRA, it only signifies the number of wetland categories in the Wicomico County study area at the first level of division for the Cowardin and others classification system.]

	Wetlands	Uplands
FWS-NWI	12,985 (8.3%)	144,208 (91.7%)
MD-WRA	17,098 (10.9%)	140,050 (89.1%)
NOAA-C-CAP	30,611 (19.5%)	126,581 (80.5%)
NRCS-WI	51,435 (32.7%)	100,007 (63.6%)

NWI classifies areas as wetlands only after they have been explicitly identified as wetlands through photointerpretation.

It can be seen from table 2 that although NOAA-C-CAP classifies less acreage within the study area as wetlands than does NRCS-WI, NOAA-C-CAP classifies more than twice the acreage within the study area as wetlands as do either FWS-NWI or MD-WRA.

Although the MD-WRA data set is used for guidance purposes, MD-WRA considers itself to be conservative in its classification of wetlands. That is, MD-WRA, like FWS-NWI, classifies areas as wetlands only after they have been explicitly identified through photointerpretation as wetlands. According to

MD-WRA: "Some marginal wetlands are missed using this approach; however, we have more confidence that the delineated wetlands are jurisdictional."[33]

The NOAA-C-CAP develops wetland data from satellite imagery as part of its change analysis program; there is no regulatory function. The amount of wetlands identified in NOAA-C-CAP depends partly on the threshold that NOAA-C-CAP uses in classifying wetlands from the satellite data. Adjustments to the threshold can affect the amount of area that NOAA-C-CAP classifies as wetlands.

The FWS-NWI, MD-WRA, and NOAA-C-CAP agree that more than 80 percent of the wetland areas in the study area are palustrine. Table 3 shows general agreement between FWS-NWI and MD-WRA in the distribution of wetland acreage in the study area.[34]

Table 3. Wetland Distribution (Acres)

	FWS-NWI	MD-WRA	NOAA-C-CAP
Palustrine	10,660 (82.1%)	14,581 (85.3)	27,629 (90.3%)
Lacustrine	546 (4.2%)	548 (3.2%)	N/A
Riverine	605 (4.7%)	853 (5.0%)	N/A
Estuarine	1,174 (9.0%)	1,116 (6.5%)	1,604 (5.2%)
Open Water	N/A	N/A	1,378 (4.5%)
Total	12,985	17,098	30,611

[33]Bill Burgess, Program Director, Enforcement Services, Water Resources Administration, State of Maryland.

[34]The NRCS-WI uses a classification system designed for compliance with the Food Security Act of 1985 and distinguishes between wetlands and farmed wetlands. More than 99 percent of the wetland area classified by NRCS-WI is classified as wetlands.

The NOAA-C-CAP classifies a greater proportion of wetlands as palustrine, but it does not explicitly classify lacustrine and riverine wetlands. Instead, it has an additional category of open water, which includes waters that may be palustrine, lacustrine, riverine, or estuarine. A more detailed summary of the wetland data is contained in appendix 2.

c. Spatial Consistency

The wetland acreage comparisons described above are useful as a general indicator of the tendency of the various data sets to classify areas as wetlands. The acreage comparisons, however, do not provide information on the extent to which the various data sets classify the same areas as wetlands and the same areas as uplands.

Table 4 summarizes the amount of agreement among the data sets in classifying the same areas as wetlands or as uplands. Each column shows the wetlands acreage agreed upon by a specific number of data sets. For instance, the 1 Data Set column represents acreage that only one data set classifies as wetlands. The 2 Data Sets column represents acreage that only two data sets agree are wetlands.

The 0 Data Sets column represents acreage that none of the four data sets are classifying as wetlands. Conversely, this represents acreage that is being classified as uplands by all four data sets. On the other hand, the 4 Data Sets column represents acreage that is being classified as wetlands by all four data sets. The sum of the 91,796 acres that are classified as uplands by all four data sets and the 5,444 acres classified as wetlands by all four data sets represents the acreage within the study area in which all four data sets agree. Thus, it can be seen that there is agreement among the four data sets in 97,240 of the 157,193 acres within the study area, or in approximately 62 percent of the study area.

The 1, 2, and 3 Data Set(s) columns represent areas that at least one data set classifies as wetlands and at least one data set classifies as uplands. These 59,953 acres, approximately 38 percent of the study area, represent the areas of disagreement among the data sets.

Table 4 shows greater agreement among the data sets in areas that are classified as uplands by at least one data set than there is in areas classified as wetlands by at least one data set. Of the 62 percent of the study area in which the four data sets agree, 94 percent is classified by the four data sets as uplands. Within areas classified by at least one data set as wetland, there is agreement among the four data sets in only eight percent of the area. On the other hand, within areas classified by at least one data set as uplands, there is

Table 4. Data Set Agreement on Wetland Designation (Acres) — Four Data Sets

[The 0 Data Set column represents acreage that none of the four data sets classify as wetland; conversely, this column represents the area that all four data sets agree are uplands. The 1 Data Set column represents the area that only one data set classifies as wetland. The 2 Data Set column represents the area that exactly two data sets classify as wetland. The 3 Data Set column represents the area that exactly three data sets classify as wetland, and the 4 Data Set column represents the area that all four data sets classify as wetland. The acreage totals do not always represent the acreage associated with the individual data sets. This is because when more than one data set classifies an area as wetland, the acreage associated with that area is only counted once. For instance, if exactly two data sets classify an area as a wetland, the acreage associated with that area will be shown for each of the two data sets. Since the area is the same for the two data sets, the acreage will only be counted once for the total.]

	0 Data Sets	1 Data Set	2 Data Sets	3 Data Sets	4 Data Sets
FWS-NWI	91,796	653	2,099	4,789	5,444
MD-WRA	91,796	1,531	3,838	6,292	5,444
NOAA-C-CAP	91,796	7,798	11,366	6,001	5,444
NRCS-WI	91,796	27,140	13,205	5,649	5,444
Totals (Acres)	91,796	37,122	15,254	7,577	5,444
Totals (Percent)	58.4%	23.6%	9.7%	4.8%	3.5%

agreement among the four sets in 60 percent. Thus, much of the apparent inconsistency among the data sets occurs in areas that at least one data set classifies as wetland.

In fact, of the area classified by one or more data sets as wetland, 57 percent is classified as wetland by only one data set. This implies that much of the apparent inconsistency occurs in areas where one data set disagrees with the others and classifies the area as wetland. It can be seen from table 4 that NRCS-WI accounts for 73 percent of the areas classified as wetland by only one data set. By comparison, FWS-NWI accounts for only 2 percent of the acreage classified as wetland by only one data set, MD-WRA accounts for 4 percent, and NOAA-C-CAP accounts for 21 percent of the acreage that is classified by only one data set as wetland. This result is consistent with the fact that NRCS-WI classifies significantly more acreage as wetlands in the Wicomico County study area than do the other data sets. On the other hand, 95 percent of the wetlands classified by FWS-NWI are also classified as wetlands by at least one other data set, and 91 percent of the wetlands classified by MD-WRA are also classified as wetlands by another data set.

Table 5 summarizes the amount of agreement among the remaining three data sets with NRCS-WI data removed from the comparison. The three data sets agree in 126,316 of the estimated 157,203 acres within the study area, or in 80 percent of the study area.[35] Again, there is more agreement in areas that at least one data set classifies as upland than in areas that are classified as wetland by at least one data set. Of the 38,258 acres classified as wetland by at least one data set, there is agreement in 7,371 acres or in 19 percent of the area. On the other hand, of the 149,832 acres classified as upland by at least one data set, there is agreement in 118,945 acres or 79 percent of the area. Areas classified by NOAA-C-CAP as wetlands represent 77 percent of the area classified as wetland by only one data set. This result is consistent with the fact that NOAA-C-CAP also classifies significantly more area as wetland in the

[35]The acreage totals reported in this analysis vary due to rounding when acreage associated with various sets of polygons are summed.

Table 5. Data Set Agreement on Wetland Designation (Acres) — Three Data Sets

[The 0 Data Sets column represents acreage that none of the four data sets classify as wetland; conversely, this column represents the area that all four data sets agree are uplands. The 1 Data Set column represents the area that only one data set classifies as wetland. The 2 Data Set column represents the area that exactly two data sets classify as wetland. The 3 Data Set column represents the area that all three data sets classify as wetland. The acreage totals do not always represent the acreage associated with the individual data sets. This is because when more than one data set classifies an area as wetland, the acreage associated with that area is only counted once. For instance, if exactly two data sets classify an area as a wetland, the acreage associated with that area will be shown for each of the two data sets. Since the area is the same for the two data sets, the acreage will only be counted once for the total.]

	0 Data Sets	1 Data Set	2 Data Sets	3 Data Sets
FWS-NWI	118,945	1,683	3,930	7,371
MD-WRA	118,945	3,717	6,019	7,371
NOAA-C-CAP	118,945	17,787	5,451	7,371
Totals (Acres)	118,945	23,187	7,700	7,371
Totals (Percent)	75.7%	14.7%	4.9%	4.7%

study area than do FWS-NWI and MD-WRA, as seen in table 2. On the other hand, 87 percent of the wetlands classified by FWS-NWI are also classified as wetlands by either MD-WRA or NOAA-C-CAP. Seventy-eight percent of the wetlands classified by MD-WRA are also classified as wetlands by either FWS-NWI or NOAA-C-CAP, and 42 percent of the wetlands classified by NOAA-C-CAP are also classified as wetlands by either FWS-NWI or MD-WRA.

Figure 2 shows the location of the six quadrangles that encompass the Wicomico County study area. Figures 3-8 illustrate the level of spatial consistency among FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI within each of the six quadrangles in the study area.

Wicomico County, Maryland

Study Area

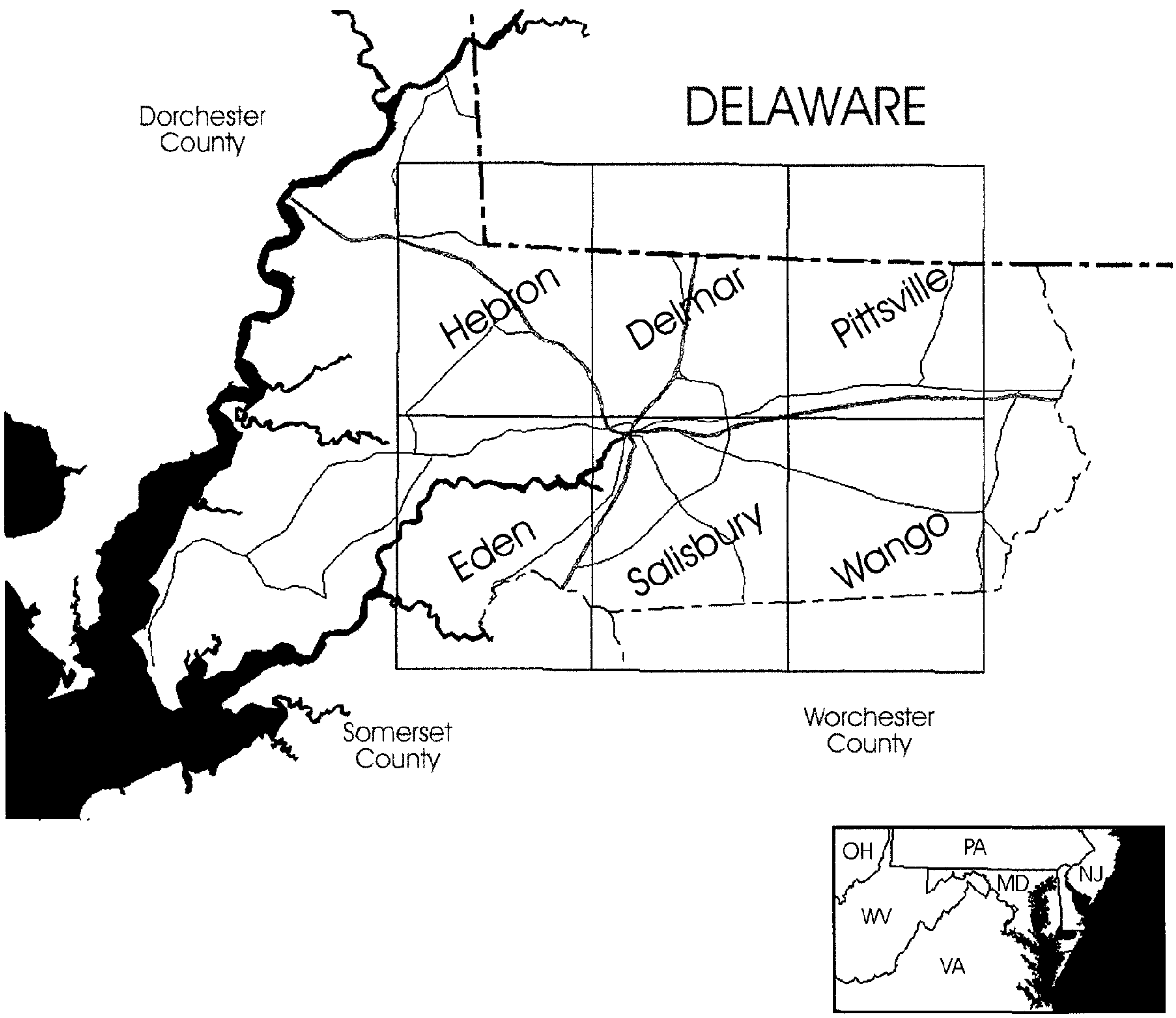


Figure 2. Portions of six USGS 7.5 minute quadrangles in Wicomico County, Maryland, encompassing the study area for the pilot data comparison.

Scale 1:370,000

Wetland Classifications - Hebron Quadrangle

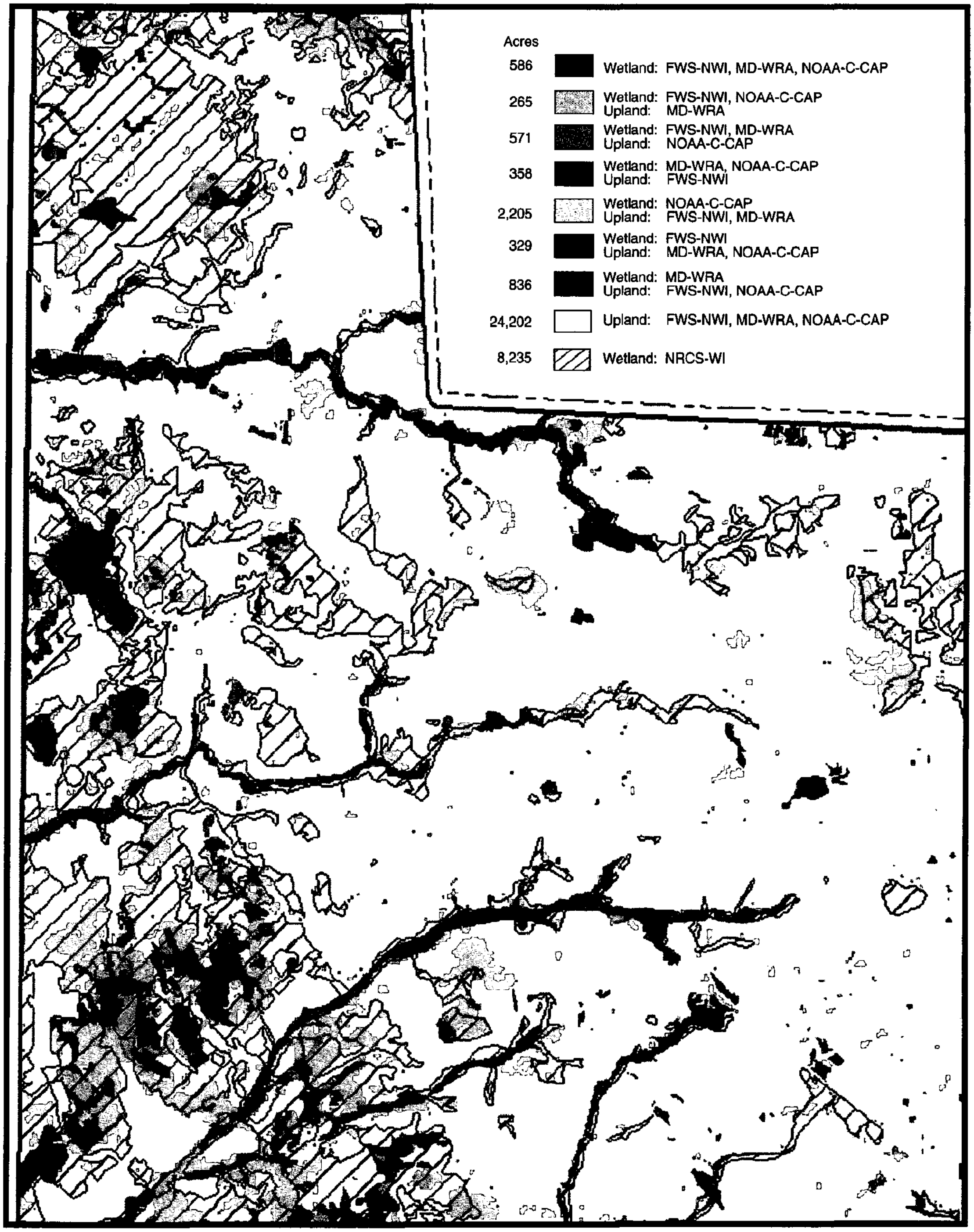
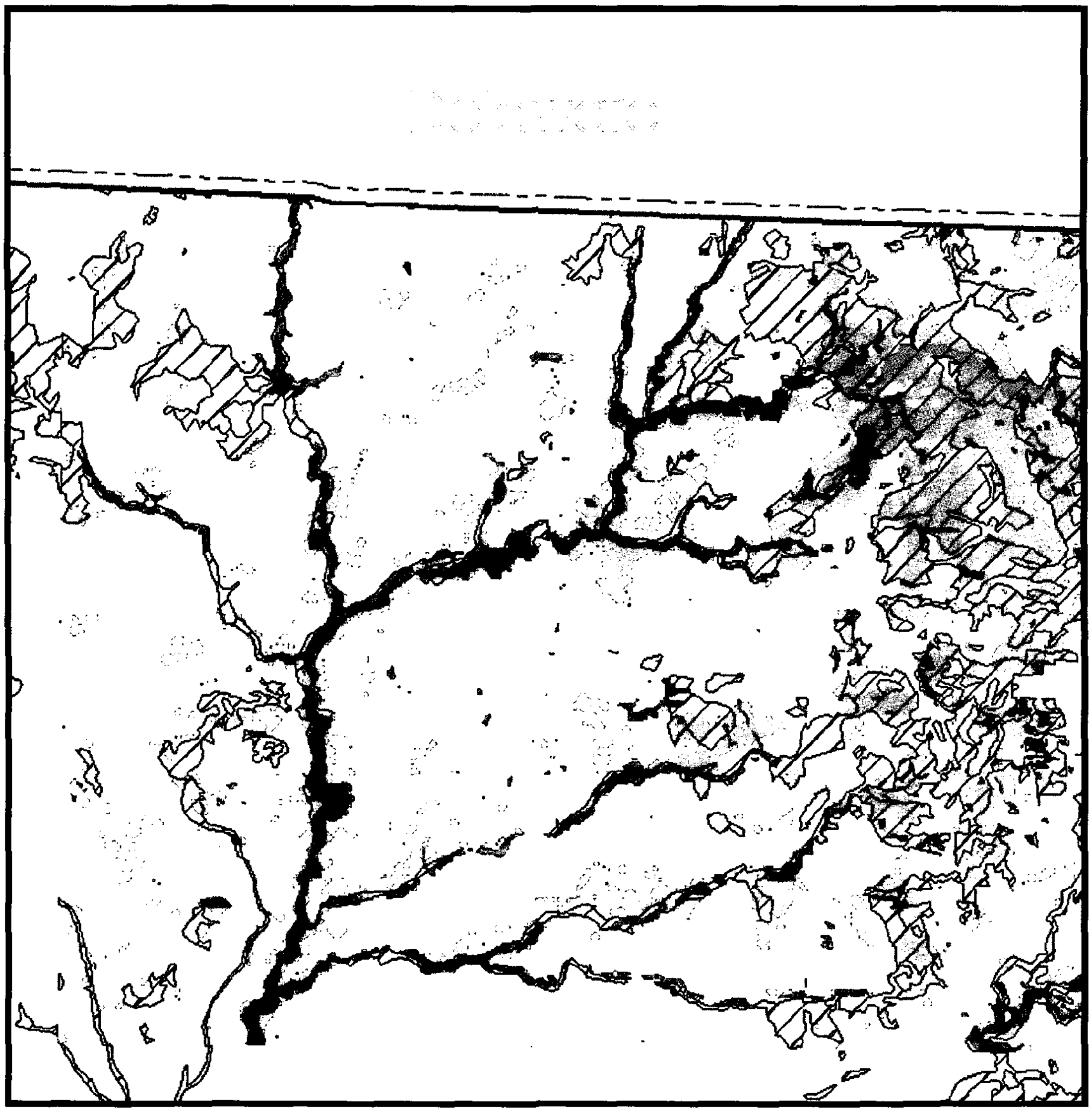


Figure 3. Scale 1:72,800

Wetland Classifications - Delmar Quad



Acres	
439	Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
114	Wetland: FWS-NWI, NOAA-C-CAP Upland: MD-WRA
222	Wetland: FWS-NWI, MD-WRA Upland: NOAA-C-CAP
375	Wetland: MD-WRA, NOAA-C-CAP Upland: FWS-NWI
2,479	Wetland: NOAA-C-CAP Upland: FWS-NWI, MD-WRA
117	Wetland: FWS-NWI Upland: MD-WRA, NOAA-C-CAP
344	Wetland: MD-WRA Upland: FWS-NWI, NOAA-C-CAP
19,648	Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
4,430	Wetland: NRCS-WI

Figure 4. Scale 1:76,000

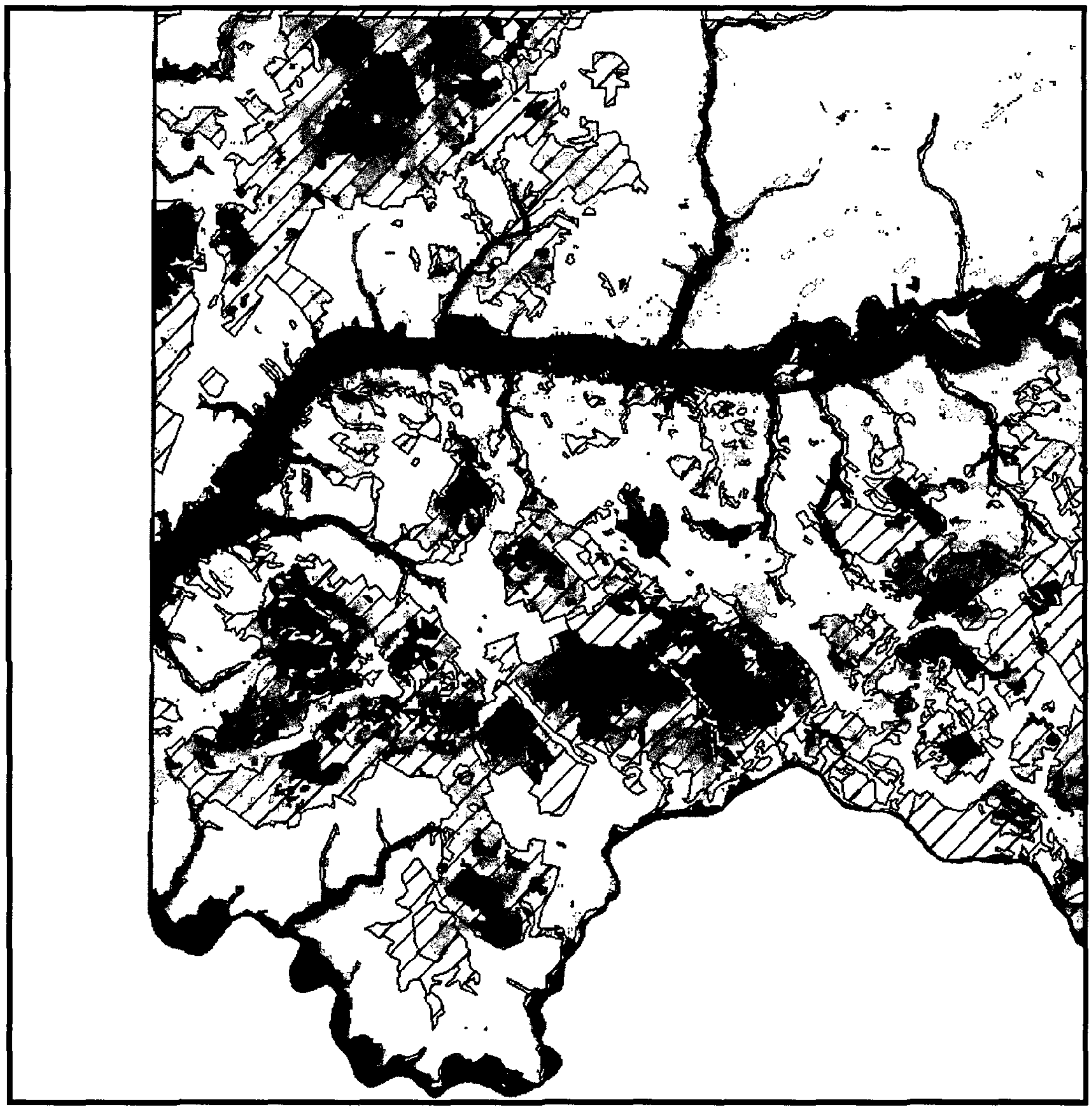
Wetland Classifications - Pittsville Quad

Acres	Class
462	Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
185	Wetland: FWS-NWI, NOAA-C-CAP; Upland: MD-WRA
170	Wetland: FWS-NWI, MD-WRA; Upland: NOAA-C-CAP
759	Wetland: MD-WRA, NOAA-C-CAP; Upland: FWS-NWI
2,714	Wetland: NOAA-C-CAP; Upland: FWS-NWI, MD-WRA
296	Wetland: FWS-NWI; Upland: MD-WRA, NOAA-C-CAP
673	Wetland: MD-WRA; Upland: FWS-NWI, NOAA-C-CAP
17,302	Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
7,178	Wetland: NRCS-WI

Figure 5.

Scale 1:73,800

Wetland Classifications - Eden Quad

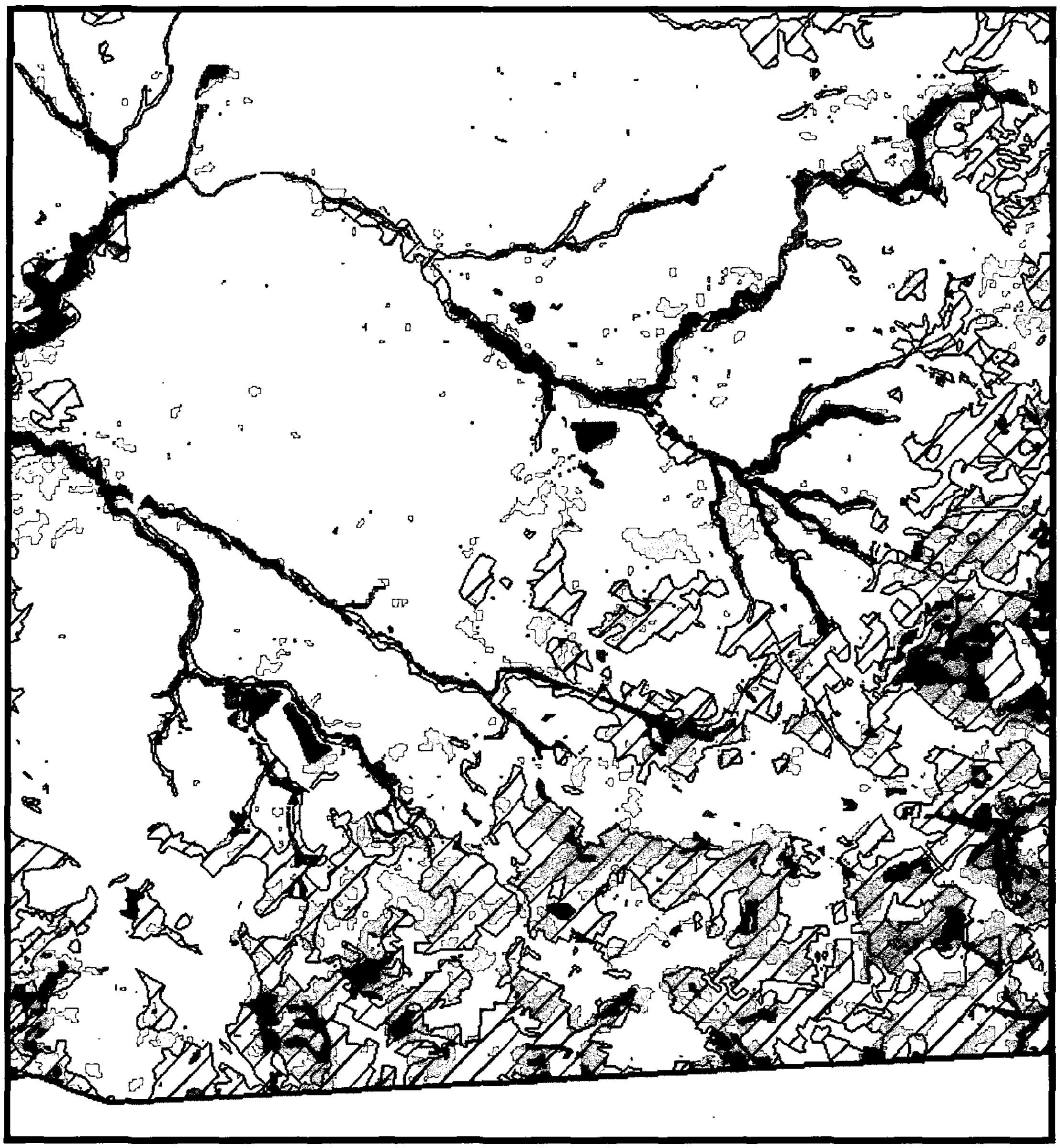


Acres	Class
2,866	Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
440	Wetland: FWS-NWI, NOAA-C-CAP; Upland: MD-WRA
723	Wetland: FWS-NWI, MD-WRA; Upland: NOAA-C-CAP
628	Wetland: MD-WRA, NOAA-C-CAP; Upland: FWS-NWI
2,293	Wetland: NOAA-C-CAP; Upland: FWS-NWI, MD-WRA
527	Wetland: FWS-NWI; Upland: MD-WRA, NOAA-C-CAP
741	Wetland: MD-WRA; Upland: FWS-NWI, NOAA-C-CAP
18,898	Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
10,745	Wetland: NRCS-WI

Figure 6.

Scale 1:82,700

Wetland Classifications - Salisbury Quad

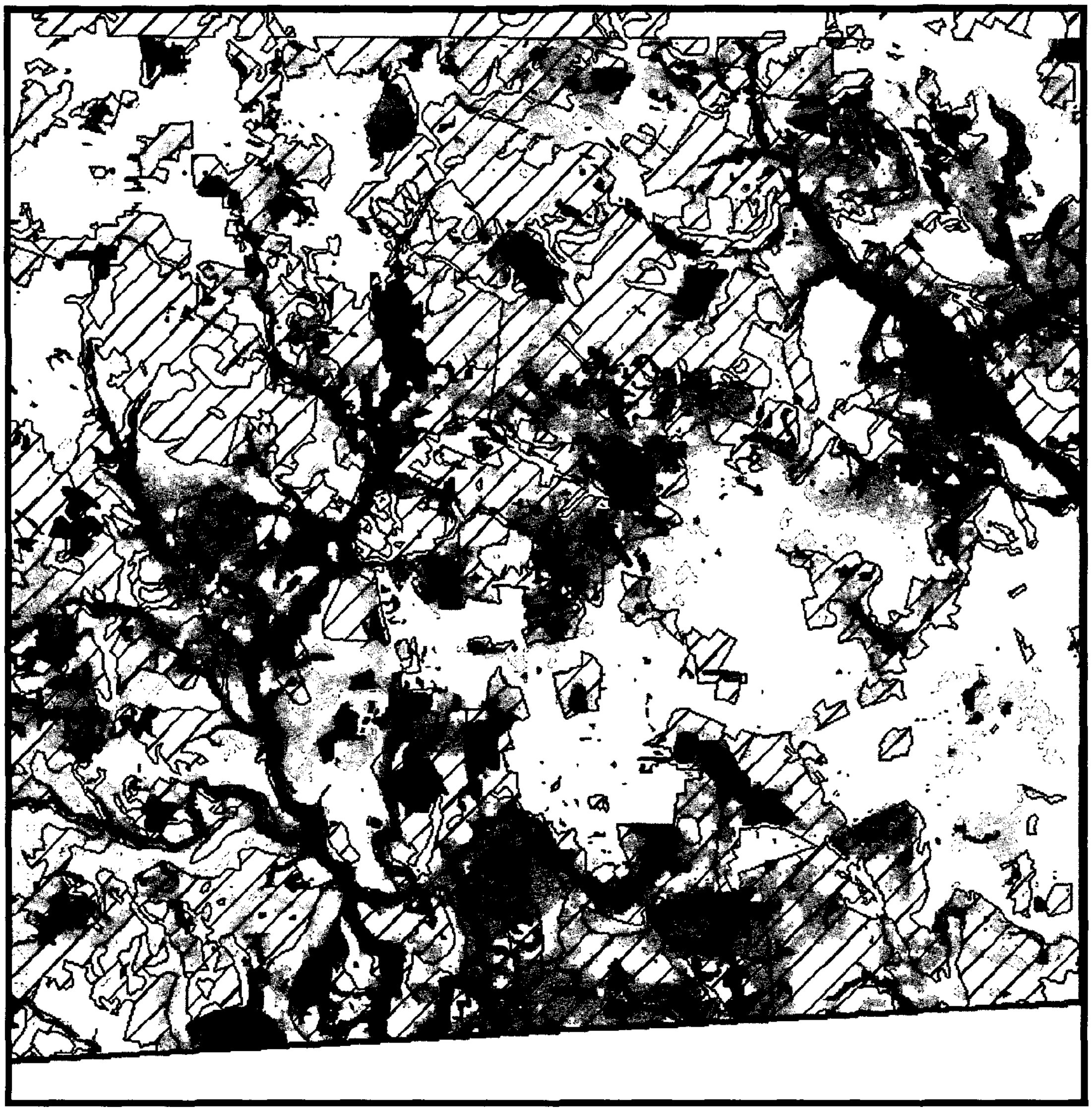


Acres	Classification	Acres	Classification	Acres	Classification
726	Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP	386	Wetland: MD-WRA, NOAA-C-CAP Upland: FWS-NWI	457	Wetland: MD-WRA Upland: FWS-NWI, NOAA-C-CAP
138	Wetland: FWS-NWI, NOAA-C-CAP Upland: MD-WRA	2,890	Wetland: NOAA-C-CAP Upland: FWS-NWI, MD-WRA	23,123	Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
310	Wetland: FWS-NWI, MD-WRA Upland: NOAA-C-CAP	153	Wetland: FWS-NWI Upland: MD-WRA, NOAA-C-CAP	7,033	Wetland: NRCS-WI

Figure 7.

Scale 1:71,400

Wetland Classifications - Wango Quad



Acres	Classification	Acres	Classification	Acres	Classification
2,292	Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP	1,264	Wetland: MD-WRA, NOAA-C-CAP Upland: FWS-NWI	661	Wetland: MD-WRA Upland: FWS-NWI, NOAA-C-CAP
539	Wetland: FWS-NWI, NOAA-C-CAP Upland: MD-WRA	5,206	Wetland: NOAA-C-CAP Upland: FWS-NWI, MD-WRA	15,681	Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
253	Wetland: FWS-NWI, MD-WRA Upland: NOAA-C-CAP	261	Wetland: FWS-NWI Upland: MD-WRA, NOAA-C-CAP	13,815	Wetland: NRCS-WI

Figure 8. Scale 1:71,400

The ungridded white area within the plots represents areas classified as upland by the four data sets. This represents approximately 58 percent of the entire study area (the sum of the area shown in figures 3-8). Within the gridded area, the dark blue area represents locations that the four data sets have all classified as wetlands, or approximately 3 percent of the study area. All other areas within the plots represent locations where there is disagreement among the data sets (approximately 38 percent of the study area).[36] The acreage associated with each color or gridded category is shown in figures 3-8 beside the color code.

The acreage totals and the plots show the relative tendency of NRCS-WI and NOAA-C-CAP to classify more area as wetlands than FWS-NWI and MD-WRA. Although each of the six quadrangles is distinct, these patterns exist for each of the quadrangles.

The matrices in tables 6-11 present information on the amount of agreement and disagreement on wetland classification for various pairs of data sets. The information contained in tables 6-11 is similar to the information presented in tables 4 and 5, but it also allows comparisons of wetland classification for specific pairs of data sets. In addition, tables 6-11 present information on consistency between data sets broken down to the system level instead of just comparing whether an area is a wetland or an upland.

Perhaps most importantly, tables 6-11 also describe the level of consistency between data sets in the classification of specific areas. As was seen in figures 3-8, there is disagreement not only in the quantity of wetlands, but on the location of wetlands. Thus, the potential for disagreement is much greater than it is for a simple acreage comparison as was presented in tables 2 and 3.

Tables 6-11 show significant disagreement in wetland classification for all pairs of data sets. This result may not be surprising for a comparison

[36]Areas classified by NRCS-WI as wetlands are shown with gridded lines rather than with a different color because areas classified as wetlands within the NRCS-WI data set include all forested areas with hydric soils. The NRCS-WI is not claiming that these areas are necessarily wetlands, but rather that these areas require further examination within NRCS-WI's regulatory responsibilities.

Table 6. Wetland Classification Comparison — FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	7,214	33	8	15	7,311	14,581
	Lac	32	458	0	0	58	548
	Riv	178	5	567	41	61	852
	Est	24	0	1	1,044	48	1,117
	Upl	3,193	49	29	74	136,705	140,050
	Total	10,641	545	605	1,174	144,183	157,148

Table 7. Wetland Classification Comparison — NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	6,624	305	49	3,681	10,659
	Lac	27	74	352	86	539
	Riv	8	88	462	47	605
	Est	25	685	347	116	1,173
	Upl	20,944	448	166	122,498	144,056
	Total	27,628	1,600	1,376	126,428	157,032

Table 8. Wetland Classification Comparison — NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	8,616	199	80	5,682	14,577
	Lac	32	75	351	86	544
	Riv	36	257	470	88	851
	Est	30	652	350	95	1,127
	Upl	18,899	438	126	120,603	140,066
	Total	27,613	1,621	1,377	126,554	157,165

Table 9. Wetland Classification Comparison — NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
NRCS-WI	**NW**	7,933	394	226	74,169	82,722
	Wet	18,247	981	277	31,782	51,287
	PC	561	18	3	16,695	17,277
	FW	0	0	0	147	147
	NC	876	208	872	3,794	5,750
	Total	27,628	1,600	1,376	126,428	157,032

Table 10. Wetland Classification Comparison — FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
	NW	1,761	151	37	63	80,716	82,728
	Wet	8,366	188	100	682	41,952	51,288
NRCS-WI	**PC**	103	4	0	24	17,146	17,277
	FW	1	0	0	0	147	148
	NC	428	204	317	406	4,248	5,603
	Total	10,659	547	454	1,175	144,209	157,044

Table 11. Wetland Classification Comparison — MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
NRCS-WI	**NW**	3,003	134	66	46	79,445	82,694
	Wet	10,841	200	292	646	39,279	51,258
	PC	345	4	1	21	16,915	17,286
	FW	6	0	0	0	144	150
	NC	394	179	493	404	4,268	5,738
	Total	14,589	517	852	1,117	140,051	157,126

between FWS-NWI data and NRCS-WI data. After all, table 2 shows that NRCS-WI classifies about four times as much area as wetlands as does FWS-NWI. The result, however, is surprising for a comparison between FWS-NWI and MD-WRA, which use similar techniques to classify wetlands and are both considered to be conservative in wetland classification.[37]

Tables 6-11 also show that a large portion of the disagreement in wetlands classification occurs in areas that are classified by one data set as palustrine wetlands. This result is due partly to the fact that most wetlands acreage in the Wicomico County study area is palustrine (see table 3). Because most of the palustrine wetlands in the study area are forested, it is also difficult to identify wetlands from aerial photographs and satellite images. In fact, it appears that remotely sensed images in forested areas obtained at different scales, with different techniques, at different times, and interpreted by different people will produce different locations of wetlands. Appendix 3 contains two-data set comparison matrices similar to those in tables 6-11 for each of the six 7.5-minute quadrangles in the study area.

Table 6 shows the extent of the disagreement between FWS-NWI and MD-WRA. It also shows that this disagreement is much more pronounced in areas classified by one of the data sets as palustrine wetlands than for other wetland systems. The MD-WRA classifies 14,581 acres as palustrine wetlands. More than half of this area, or 7,311 acres, is classified by FWS-NWI as uplands. Most of the disagreement between FWS-NWI and MD-WRA is not among wetland systems, but rather, between the wetland and the upland classification. Similarly, FWS-NWI classifies 10,641 acres as palustrine wetlands. Although FWS-NWI classifies almost 4,000 less acres as palustrine wetlands, MD-WRA classifies as uplands more than 3,000 of the acres classified by FWS-NWI as palustrine wetlands.

[37]The FWS-NWI used 1:58,000-scale color infrared aerial (CIR) photographs and MD-WRA used 1:40,000-scale CIR photographs. It takes approximately 3 aerial photographs at the 1:58,000 scale and 10 aerial photographs at the 1:40,000 scale to provide stereoscopic coverage for a 7.5-minute quadrangle area. FWS comments: "Apparently a bluish cast on the 1982 1:58,000-scale CIR photographs used by FWS-NWI masked the drier wetland signature."

The level of agreement between FWS-NWI and MD-WRA is much greater for types of wetlands other than palustrine. More than 90 percent of areas classified as lacustrine, riverine, or estuarine wetlands by FWS-NWI are also classified as wetlands by MD-WRA. The percentages are similar for areas classified as lacustrine, riverine, or estuarine by MD-WRA. Again, more than 90 percent of the area classified as riverine or estuarine by MD-WRA is classified as wetlands by FWS-NWI. The percentage for lacustrine wetlands is approximately 89 percent.

As tables 4 and 5 show, there is significantly more disagreement in areas that at least one data set classifies as wetlands than there is in areas that at least one data set classifies as uplands. In table 6, of the 140,050 or 144,183 acres classified as uplands by MD-WRA or FWS-NWI respectively, the two data sets agree in 136,705 acres. A similar pattern can be seen in tables 7 and 8, which compare NOAA-C-CAP data with FWS-NWI and MD-WRA. Again, there is significant disagreement in the areas classified as palustrine wetlands. For instance, of the 27,628 acres classified by NOAA-C-CAP as palustrine wetlands, FWS-NWI agrees in only 6,624 of those acres. The FWS-NWI classifies more than 20,000 of the remaining acres as uplands. Although FWS-NWI classifies less than half the acreage as palustrine wetlands as does NOAA-C-CAP, 3,681 of the 10,659 acres classified by FWS-NWI as palustrine wetlands are classified by NOAA-C-CAP as uplands.

For wetland types other than palustrine, there is again a significantly greater amount of agreement on a wetland/upland basis between FWS-NWI and NOAA-C-CAP and between MD-WRA and NOAA-C-CAP. For instance, more than 80 percent of the area classified by FWS-NWI as lacustrine, riverine, or estuarine is classified as wetlands by NOAA-C-CAP. More than 70 percent of the area classified as estuarine or open water by NOAA-C-CAP is classified as wetlands by FWS-NWI. This compares to the fact that less than one-quarter of the area classified as palustrine by NOAA-C-CAP is classified as wetlands by FWS-NWI. Again, the fact that the great majority of areas classified as wetlands by FWS-NWI, MD-WRA, and NOAA-C-CAP are classified as palustrine wetlands drives the results in the general wetland/upland classification comparison.

Tables 7 and 8 show that the level of agreement between NOAA-C-CAP and FWS-NWI and between NOAA-C-CAP and MD-WRA in upland classification is much greater than it is in wetland classification. For instance, FWS-NWI and NOAA-C-CAP agree in 122,498 of the 126,428 acres classified as uplands by NOAA-C-CAP and of the 144,056 acres classified as uplands by FWS-NWI.

Tables 9-11 compare data from NRCS-WI with data from FWS-NWI, MD-WRA, and NOAA-C-CAP. In these comparisons, more than 65 percent of the area classified as palustrine wetlands by FWS-NWI, MD-WRA, and NOAA-C-CAP is also classified as wetlands by NRCS-WI. This is consistent with the fact that NRCS-WI appears to have a greater tendency to classify an area as a wetland than do the other data sets. On the other hand, more than 60 percent of the area classified as wetlands by NRCS-WI, is classified as uplands by FWS-NWI, MD-WRA, and NOAA-C-CAP. As was the case in tables 6-8, there is agreement between pairs of sets in most of the areas that are classified by either of the data sets as uplands.

Comparisons were also made between data from NRCS-NRI and FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI. These comparisons are somewhat different than the comparisons summarized in tables 6-11 because the NRCS-NRI consists of point data rather than areal data. For comparisons of the NRCS-NRI data with the other data sets, it is necessary to compare the classification from the two data sets at the NRCS-NRI points. To allow for possible positional errors, two comparisons are made. The first comparison occurs at the NRCS-NRI point itself. For the second comparison, a 50-meter diameter buffer is drawn around the NRCS-NRI point. If the other data set is consistent with the NRCS-NRI point anywhere within the 50-meter buffer, the data are considered consistent for this comparison.

Table 12 summarizes the comparisons made between the NRCS-NRI data and the other wetland data sets. The NRCS-NRI classifies 74 of its 243 data points as wetlands and the remaining 169 points as uplands. Only NRCS-WI classifies more of these points as wetlands. In fact, NRCS-NRI classifies more points as wetlands than do FWS-NWI, MD-WRA, and NOAA-C-CAP combined.

Table 12. Wetland Classification Comparison — NRCS-NRI/Other Data (Points)

[Shaded areas represent points of agreement between NRCS-NRI and other data sets. The numbers in the parentheses are based on the assumption that if there is agreement anywhere within the 50-meter buffer, the data from the two data sets agree.]

		NRCS-NRI Wetlands	NRCS-NRI Uplands	NRCS-NRI Totals
FWS-NWI	Wetlands	8 (25)	2 (0)	10 (25)
	Uplands	66 (49)	167 (169)	233 (218)
	Totals	74 (74)	169 (169)	243 (243)
MD-WRA	Wetlands	12 (30)	2 (0)	14 (30)
	Uplands	62 (44)	167 (169)	229 (213)
	Totals	74 (74)	169 (169)	243 (243)
NOAA-C-CAP	Wetlands	21 (51)	10 (2)	31 (53)
	Uplands	53 (23)	159 (167)	212 (190)
	Totals	74 (74)	169 (169)	243 (243)
NRCS-WI	Wetlands	59 (67)	18 (5)	77 (72)
	Uplands	13 (5)	145 (158)	158 (163)
	No Data	2 (2)	6 (6)	8 (8)
	Totals	74 (74)	169 (169)	243 (243)

The NRCS-NRI is relatively consistent with FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI for points classified by these data sets as wetlands. For instance, NRCS-NRI agrees with FWS-NWI in 8 out of the 10 points classified as wetlands by FWS-NWI. In fact, with the 50-meter buffer, NRCS-NRI agrees with all of the wetland points identified by FWS-NWI and MD-WRA.

The NRCS-NRI is also relatively consistent with the other data sets for points that it classifies as uplands. Of the 169 points classified by NRCS-NRI as uplands, FWS-NWI and MD-WRA agree with the classification at 167 of the points. Again, with the 50-meter buffer, FWS-NWI and MD-WRA agree at all 169 points classified by NRCS-NRI as uplands.

The results suggest that although NRCS-NRI may have a tendency to identify more points as wetlands than FWS-NWI, MD-WRA, and NOAA-C-CAP, NRCS-NRI does classify as wetlands most of the points classified as wetlands by the other data sets. In addition, partly owing to NRCS-NRI's tendency to classify more points as wetlands, the other data sets agree for the most part with points classified by NRCS-NRI as uplands. Because NRCS-NRI classifies relatively more points as wetlands, there is disagreement for many of the points it classified as wetlands.

d. Field Tests

The results from the two field tests support the hypothesis that although there are significant inconsistencies among the data sets both in total acreage classified as wetlands and in the location of the wetlands, the disagreements to some extent appear to be related to the tendency of some data sets to classify areas (or points for the NRCS-NRI) as wetlands. A summary of the results from the first field test is shown in table 13. More detailed data from the field test are contained in appendix 4. As was discussed in the Methodology section, in the first test, an independent contractor evaluated 130 points selected by the working group to determine whether or not the points

Table 13. Wetland Data Comparison — First Field Test/Wetland Data Sets (Points)

[Shaded areas represent agreement between the data set and the field test results. Numbers in parentheses represent data set potential agreement with field test points if there is a wetland boundary within 50 meters of the point. If there is a wetland boundary within 50 meters of the point, the field test point is assumed to agree with the agency data set.]

		Field Test				
		Wetlands		Uplands		Totals
FWS-NWI	Wetlands	8	(11)	6	(3)	14
	Uplands	33	(9)	83	(107)	116
	Totals	41		89		130
MD-WRA	Wetlands	11	(14)	6	(3)	17
	Uplands	30	(9)	83	(104)	113
	Totals	41		89		130
NOAA-C-CAP	Wetlands	11	(20)	23	(14)	34
	Uplands	30	(8)	66	(88)	96
	Totals	41		89		130
NRCS-WI	Wetlands	30	(48)	46	(28)	76
	Uplands	10	(2)	41	(49)	51
	Totals	40		87		127
NRCS-NRI	Wetlands	11	(19)	26	(18)	37
	Uplands	5	(1)	19	(23)	24
	Totals	16		45		61

were within wetlands.[38] Figure 9 shows the spatial distribution of the points examined in the first field test.

Table 13 shows that NRCS-WI and NRCS-NRI classified as wetlands well over half of the points that the contractor identified as wetlands.[39] On the other hand, FWS-NWI, MD-WRA, and NOAA-C-CAP all classified as wetlands less than a third of the points that the contractor identified as wetlands. This result is consistent with a general pattern of NRCS-WI and NRCS-NRI having a greater tendency to identify wetlands. Likewise, FWS-NWI, MD-WRA, and NOAA-C-CAP all classified as uplands well over half of the points that the contractor identified as not wet. On the other hand, NRCS-WI and NRCS-NRI both classified as uplands (or not wet) less than half of the points that the contractor identified as not wet.

A related issue in wetlands identification is the success of the data sets in correctly identifying wetlands. That is, what percentage of the points identified as wetlands by the various data sets are actually wetlands? More than half of the points classified as wetlands by the more conservative data sets, FWS-NWI and MD-WRA, were found by the contractor to actually be wetlands. Of the points identified as wetlands by NOAA-C-CAP, NRCS-WI, and NRCS-NRI, less than one-third of the points classified as wet by NOAA-C-CAP and NRCS-NRI were identified as wet by the contractor and less than one-half of the points classified by NRCS-WI as wet were found to be wet in the field test.

Errors in the delineation of wetlands can be classified into two distinct categories: Type I errors, or errors of omission, and type II errors, or errors of commission. Type I errors, or errors of omission, occur when a wetland is delineated in a data set as an upland. Type II errors, or errors of commission, occur when an upland is delineated as a wetland.

The results from the first field test support the hypothesis that data sets with a greater tendency to classify an area as a wetland make less errors of

[38]The independent contractor was EcoScience Professionals, Inc.

[39]The NRCS-NRI has less total points than the other data sets because only 61 of the 130 test points coincided with NRCS-NRI points.

FIRST FIELD TEST:

Spatial Distribution of Points

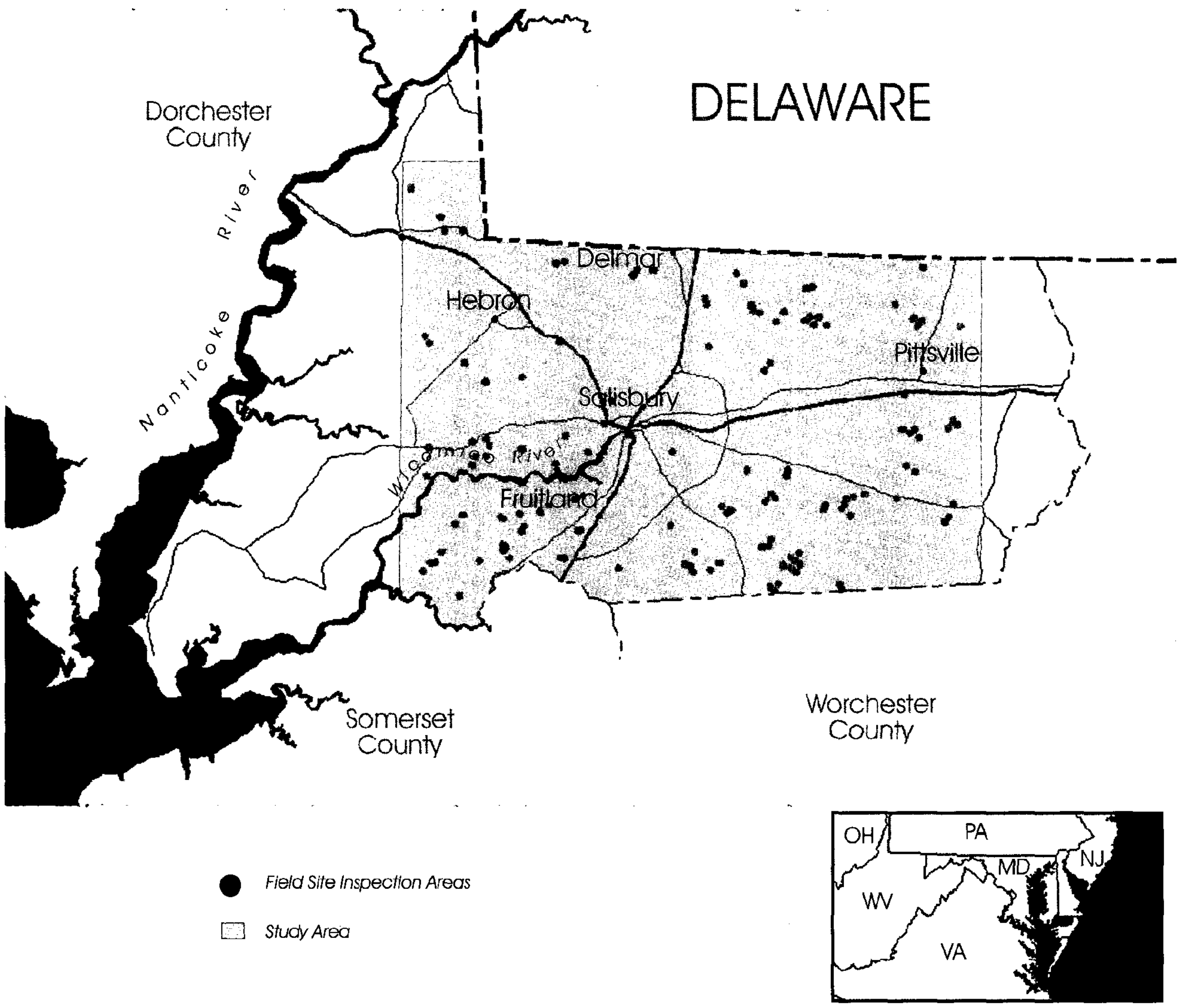


Figure 9. 130 points were evaluated in the study area to determine whether they were wetlands or uplands.

Scale 1:370,000

omission and more errors of commission. That is, these data sets identify more of the wetland areas, but they also classify more uplands as wetlands. On the other hand, the results also support the hypothesis that the data sets that are more conservative in wetland delineation make less errors of commission and more errors of omission. In this case, less of the wetland areas are identified, but more of the areas classified as wetlands are actually wetlands. It should be emphasized that these results depend on the assumption that the field test results are correct. It should also be emphasized that these results do not represent a statistically significant analysis; rather, the results provide information that can be used to interpret and to design future tests of hypotheses.

During the field test, the contractor evaluated whether or not a boundary change in wetland/upland designation existed within 50 meters of the point. Of the 130 points, 67 were found to be within 50 meters of a boundary change. The numbers in parentheses in table 13 represent revised field test point designations for points within the 50-meter boundary change where a change would cause the field classification to be consistent with the data set classification. Thus, the numbers in parentheses represent an assumption that the inconsistency between the field test points and the data set points are caused by potential errors in ground truth (either by the data set or by the contractor) or by ambiguities in wetland classification caused by boundary problems. The numbers in the parentheses represent the best possible interpretation of the results—that the boundary change causes inconsistent results to be consistent.

As expected, in table 13 the numbers in parentheses show improved consistency between the field test and the data sets. For instance, with the boundary changes, the contractor agrees with FWS-NWI in 107 out of 116 points classified by FWS-NWI as uplands. Likewise, the boundary changes cause the contractor results to agree with 49 out of 51 points classified as uplands by NRCS-WI.

A comparison of the contractor results with the NRCS soil survey in Wicomico County shows that the contractor disagreed with the survey in 25 percent of the points. This is significant because NRCS-WI delineated forested areas in Wicomico County as wetland if the soils were hydric. In addition, FWS-NWI, MD-WRA, and NRCS-NRI use the soil survey as ancillary data.

Because many of the results in the first field test were sensitive to boundary changes, the working group examined points at 100-foot intervals on transects in the second field test. The working group conducted field investigations on July 13-14, 1993, to gather field data to compare with the agency data sets. The field team included representatives from the FWS, NRCS, NOAA, MD-WRA, EPA, and USGS. The working group identified nine sites and designed transects of between 100 feet and 2,200 feet. The location of the transects is shown in figure 10. For each transect examined, a field team from the working group used a compass and a tape measure to measure 100-foot intervals perpendicular to the point of entry (usually a road). In addition to wetlands and uplands, a third category, transitional, was used in the field test to classify areas that are between wetland and upland areas and have characteristics of both.[40]

The transects examined during the working group field trip are illustrated in figures 11-22. For each test site, the first figure is part of a color-enhanced digital orthophoto quarterquadrangle showing the land characteristics of the area surrounding the test sites. The second figure shows whether or not FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI classified the area surrounding the point as wetland or upland. This figure shows areas of agreement and disagreement between the data sets' wetland classifications.

Figure 12 shows the wetland classifications by the various agencies for sites A and A'. The purpose of this investigation was to examine an area that NOAA-C-CAP and NRCS-WI identified as wetland, but that FWS-NWI and MD-WRA identified as upland. Transect A' was designed to be near the boundary separating areas classified as wetlands and as uplands by NOAA-C-CAP.

As seen from figure 11, the field team entered transect A from State Route 350 at 210 degrees and walked 200 feet, with examinations at 100 and

[40]A single point in the test on transect G was classified during the field test as a drained wetland.

SECOND FIELD TEST

Spatial Distribution of Transects

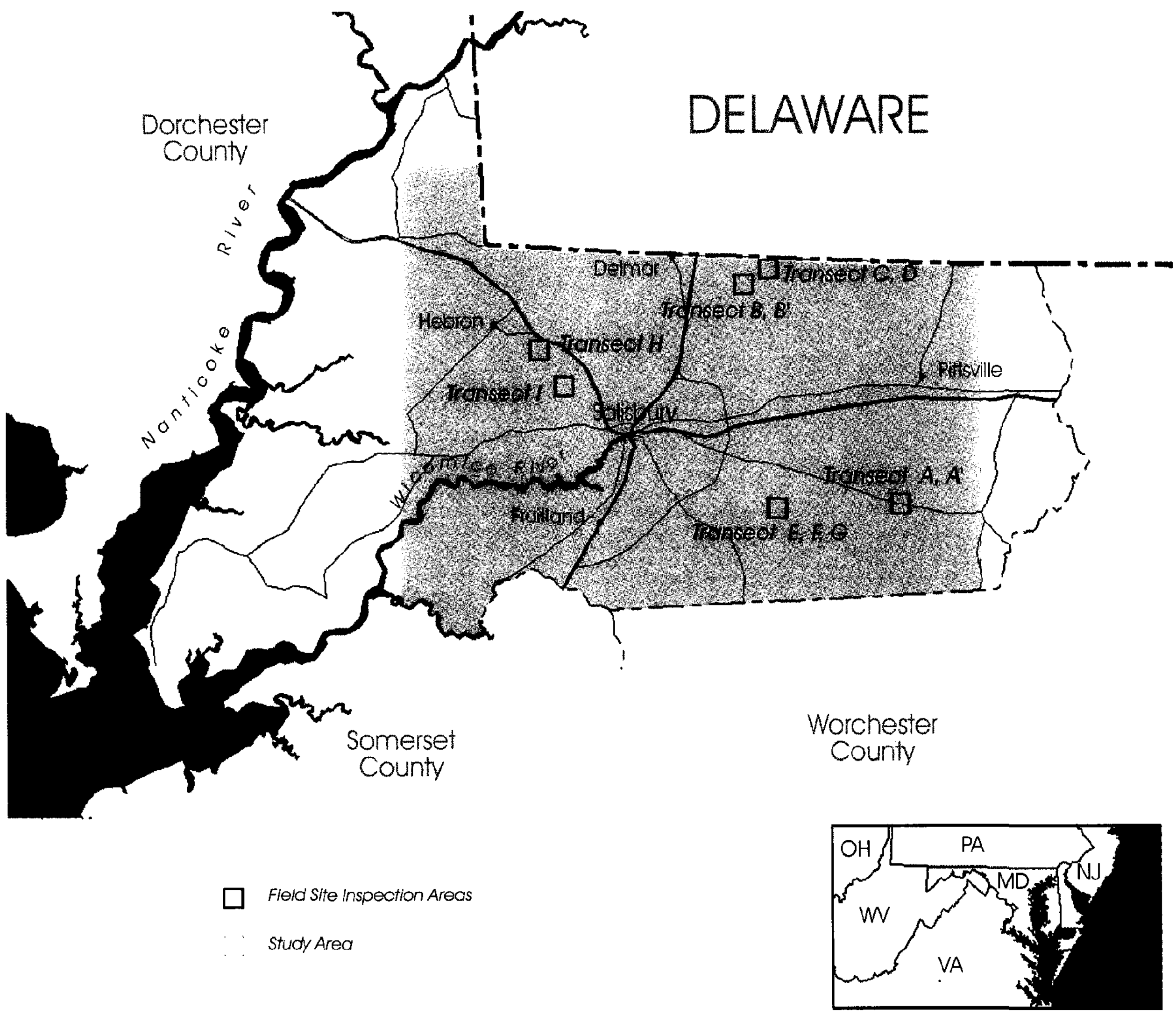
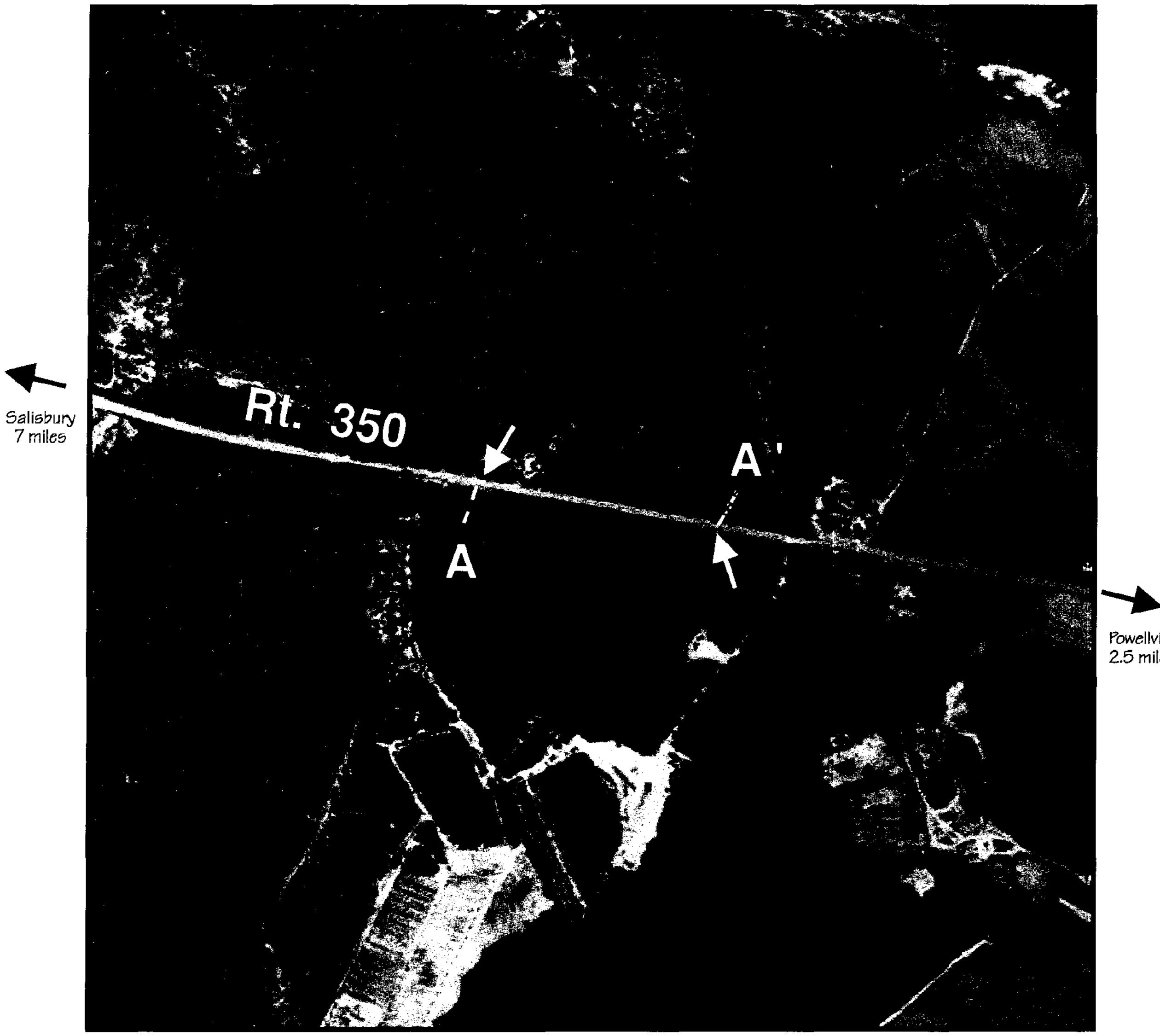


Figure 10. Points at nine transect sites were evaluated to determine whether they were wetlands or uplands.

Scale 1:370,000

Transects A, A´



Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 11. **Scale 1:9,012**

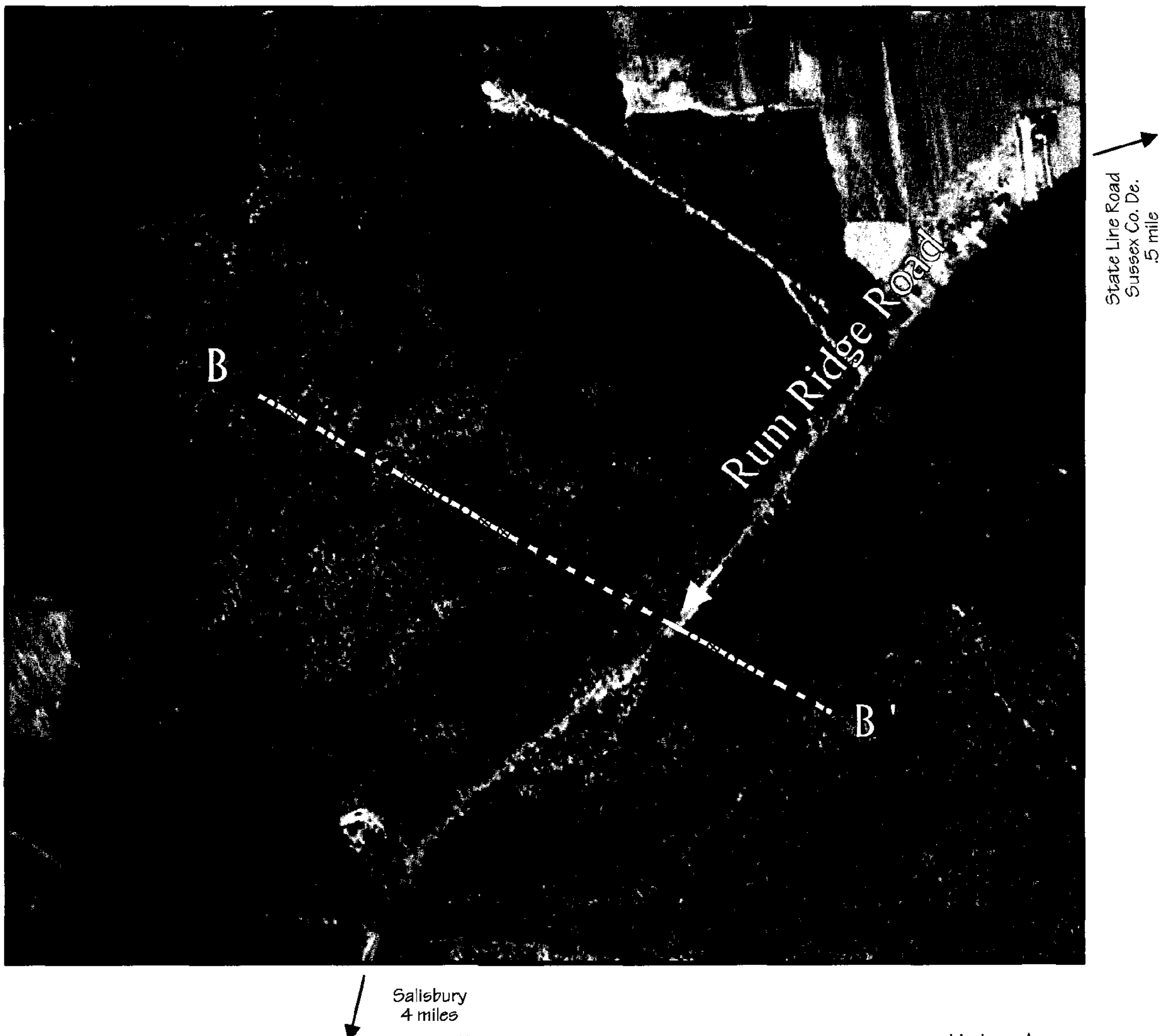
Wetland Data Set Comparison
Transects A, A´

Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
Wetland: MD-WRA, NOAA-C-CAP Upland: FWS-NWI
Wetland: MD-WRA Upland: FWS-NWI, NOAA-C-CAP
Wetland: FWS-NWI, NOAA-C-CAP Upland: MD-WRA
Wetland: NOAA-C-CAP Upland: FWS-NWI, MD-WRA
Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
Wetland: FWS-NWI, MD-WRA Upland: NOAA-C-CAP
Wetland: FWS-NWI Upland: MD-WRA, NOAA-C-CAP
Wetland: NRCS-WI

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 12. Scale 1:9,012

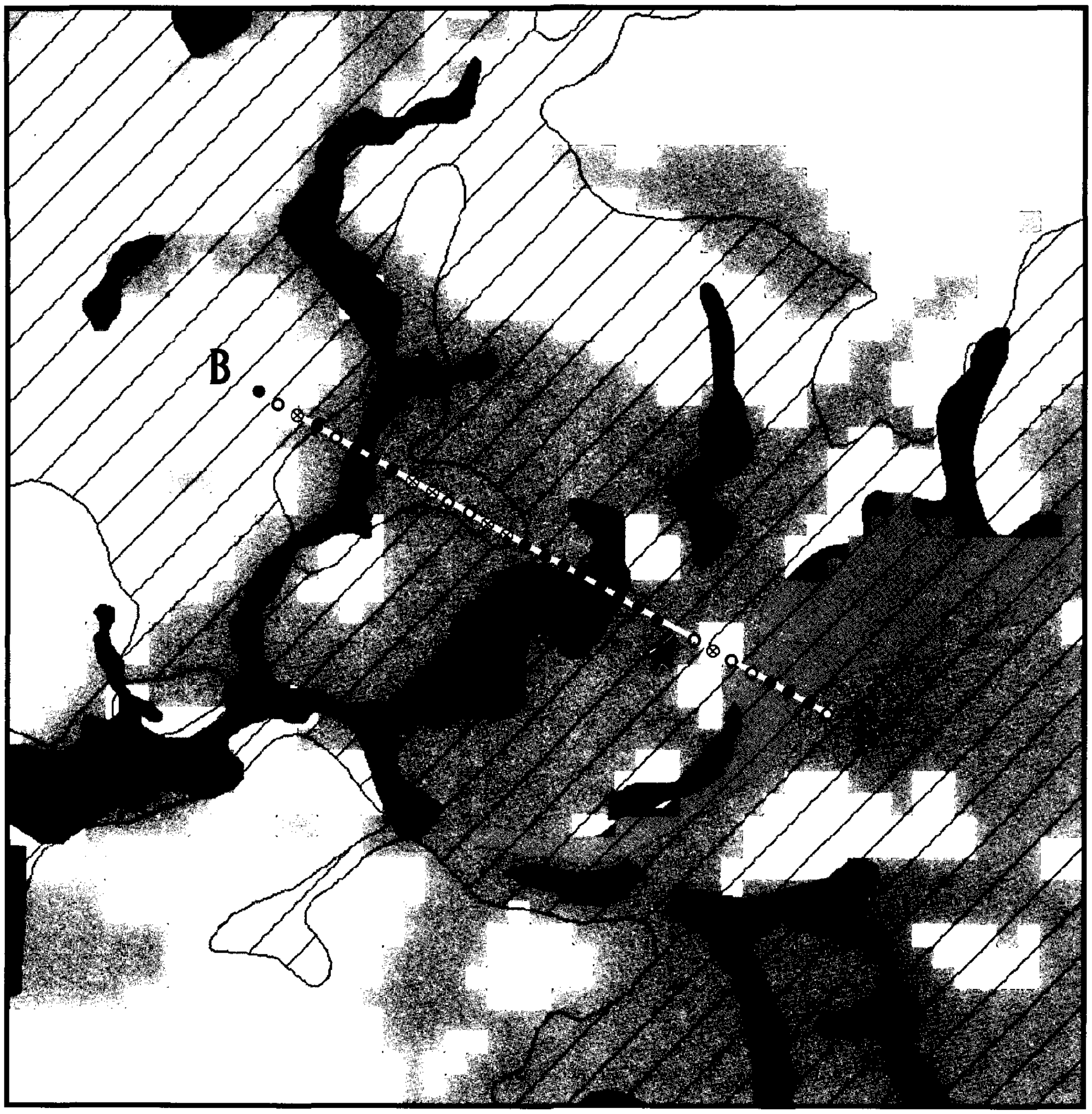
Transects B, B´



Field Evaluation: • Wetland ⊗ Transitional o Upland

Figure 13. **Scale 1:10,080**

Wetland Data Set Comparison
Transects B, B´

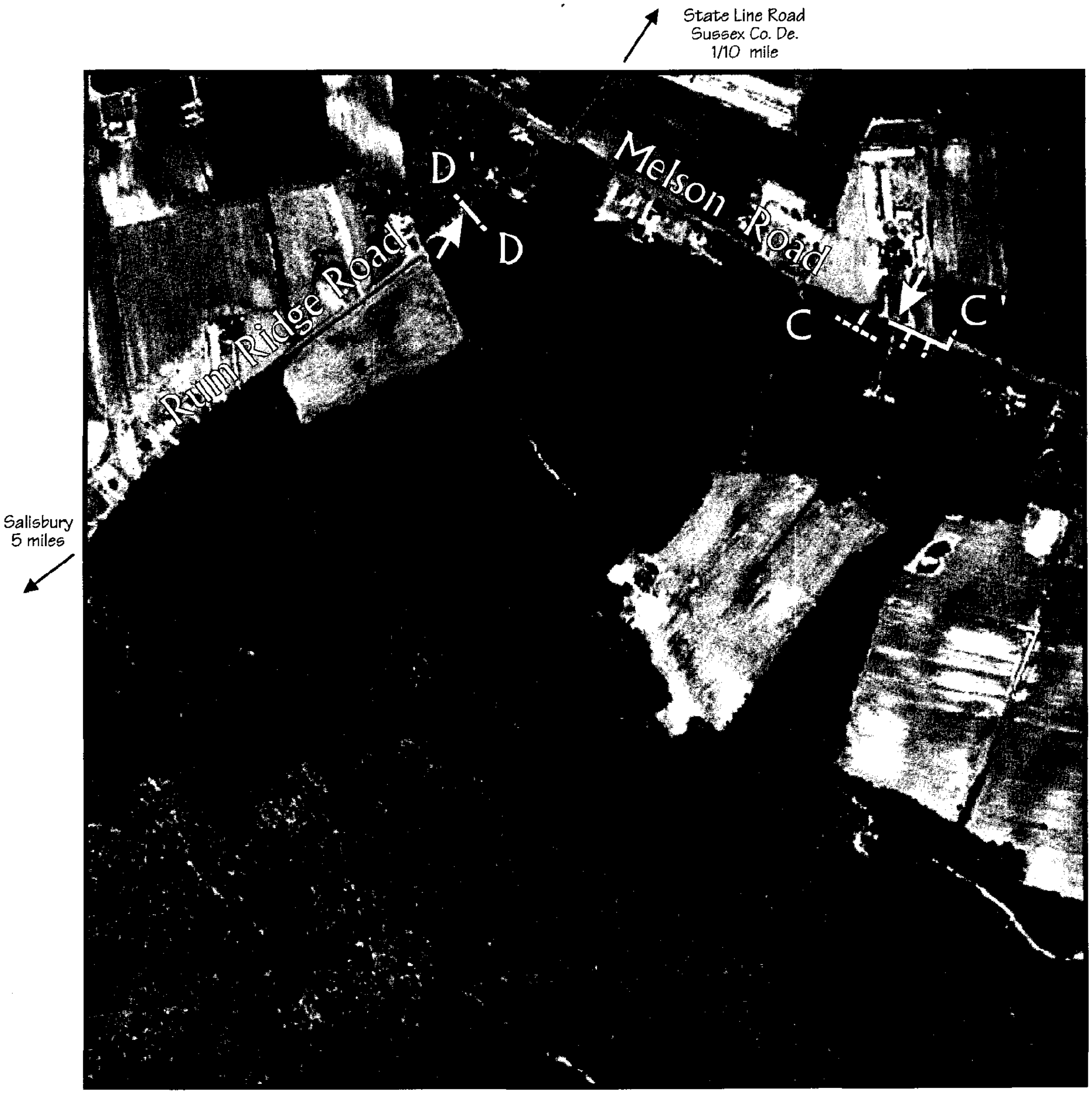


- Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: FWS-NWI, NOAA-C-CAP
  Upland: MD-WRA
- Wetland: FWS-NWI, MD-WRA
  Upland: NOAA-C-CAP
- Wetland: MD-WRA, NOAA-C-CAP
  Upland: FWS-NWI
- Wetland: NOAA-C-CAP
  Upland: FWS-NWI, MD-WRA
- Wetland: FWS-NWI
  Upland: MD-WRA, NOAA-C-CAP
- Wetland: MD-WRA
  Upland: FWS-NWI, NOAA-C-CAP
- Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: NRCS-WI

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 14 **Scale 1:10,080**

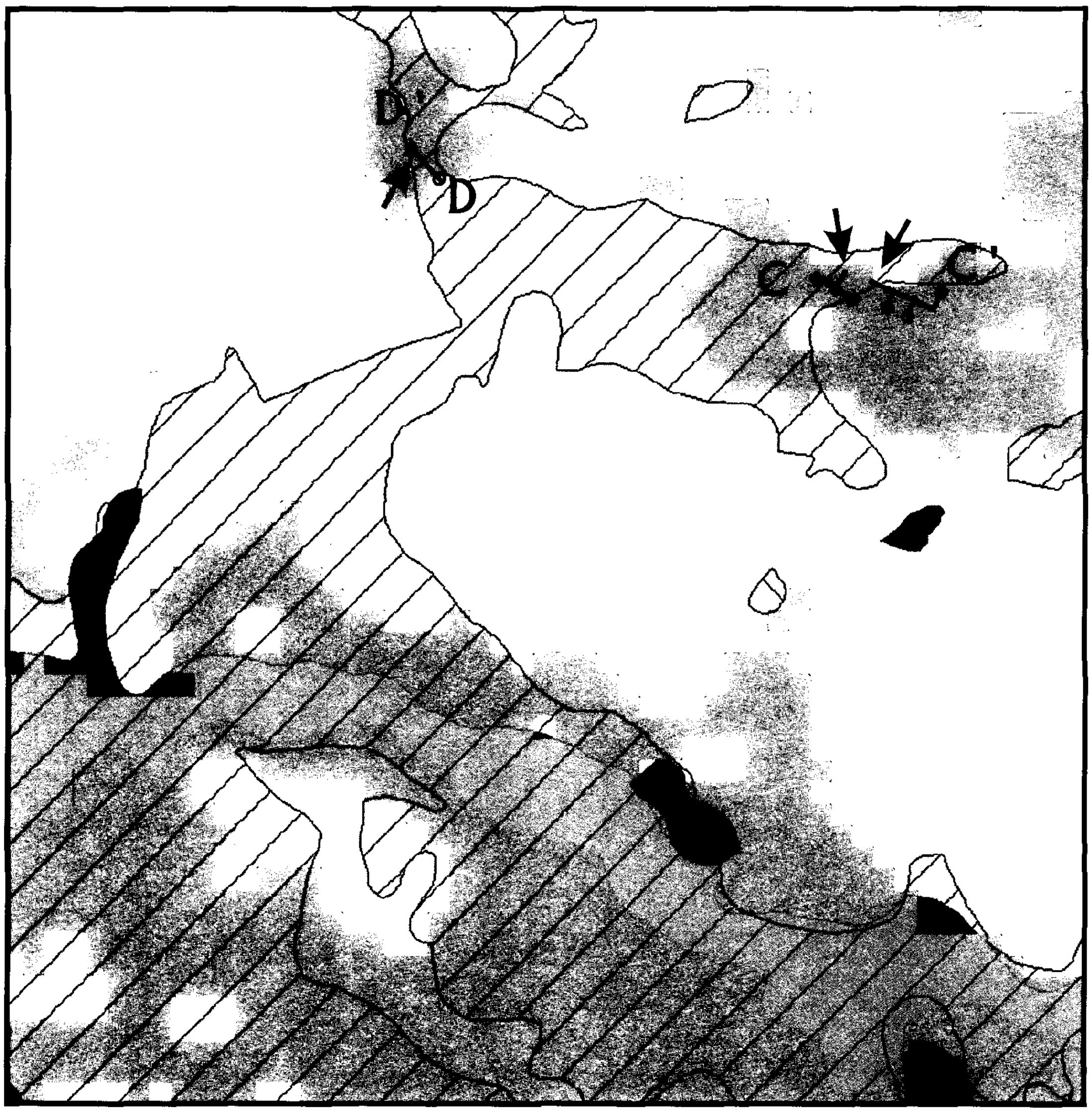
Transects C, D



Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 15. **Scale 1:10,759**

Wetland Data Set Comparison
Transects C, D



- Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: MD-WRA, NOAA-C-CAP / Upland: FWS-NWI
- Wetland: MD-WRA / Upland: FWS-NWI, NOAA-C-CAP
- Wetland: FWS-NWI, NOAA-C-CAP / Upland: MD-WRA
- Wetland: NOAA-C-CAP / Upland: FWS-NWI, MD-WRA
- Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: FWS-NWI, MD-WRA / Upland: NOAA-C-CAP
- Wetland: FWS-NWI / Upland: MD-WRA, NOAA-C-CAP
- Wetland: NRCS-WI

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 16 Scale 1:10,759

Transects E, F, G

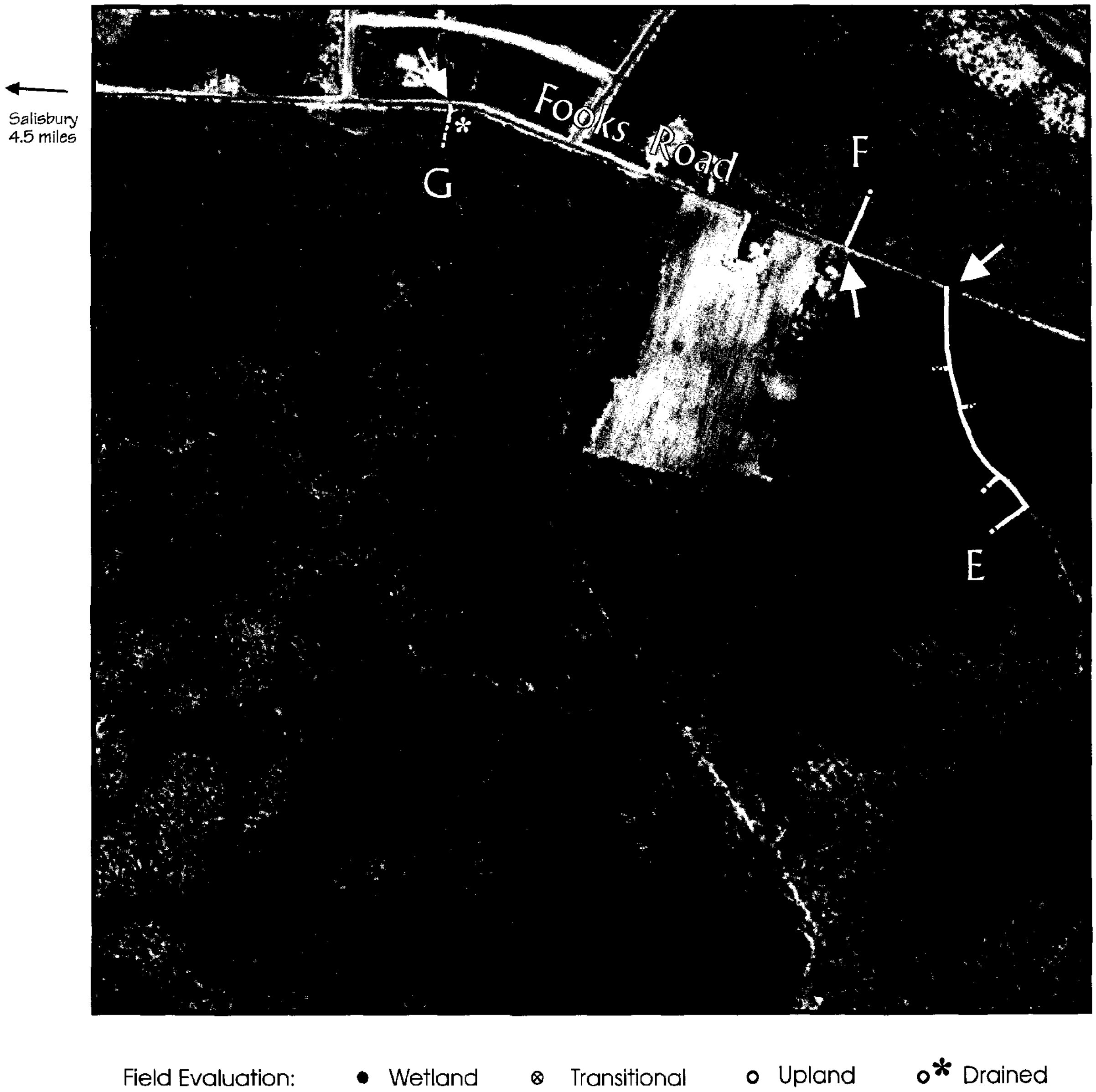
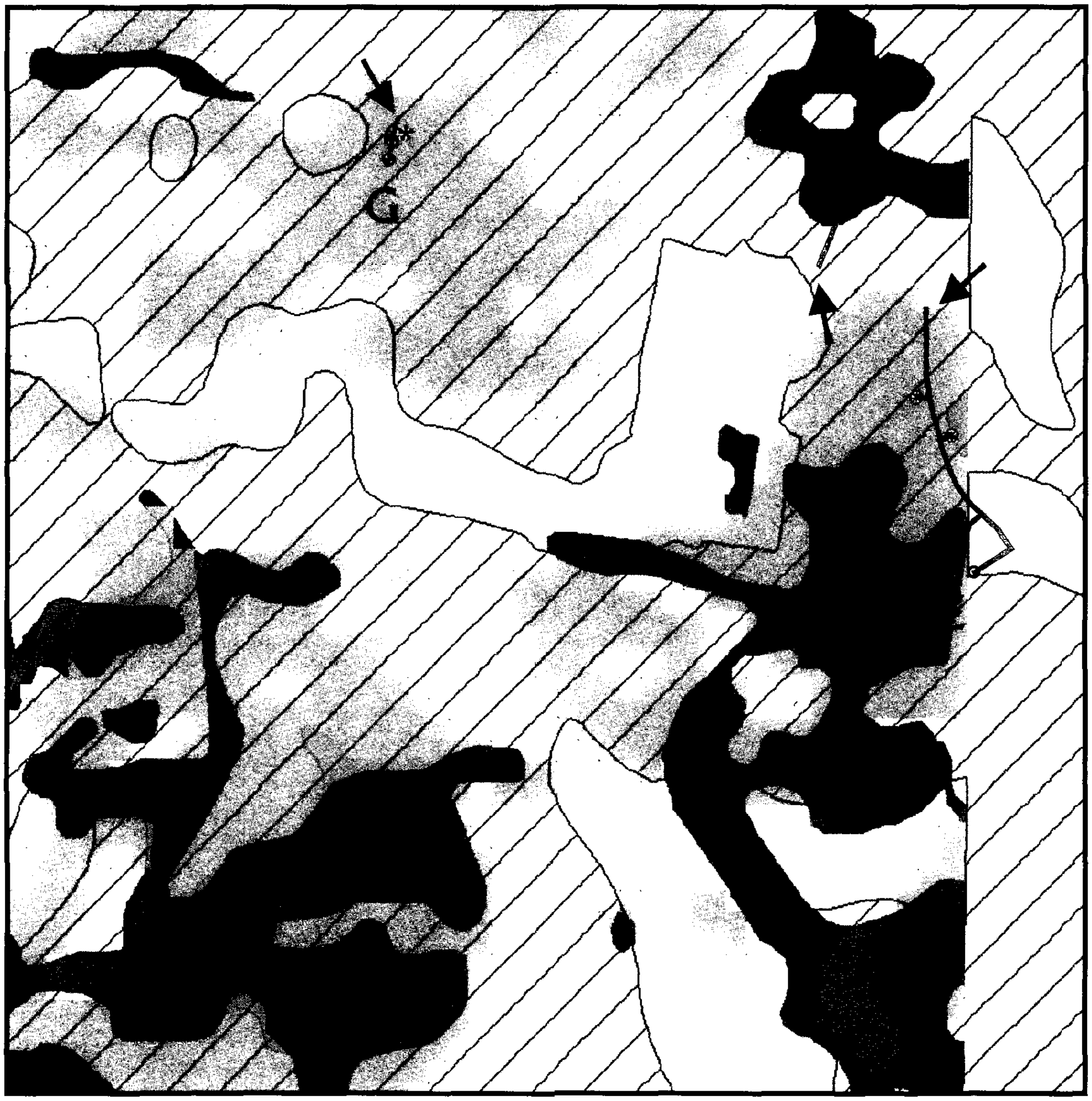


Figure 17. **Scale 1:9,600**

Wetland Data Set Comparison
Transects E, F, G



Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP

Wetland: FWS-NWI, NOAA-C-CAP
Upland: MD-WRA

Wetland: FWS-NWI, MD-WRA
Upland: NOAA-C-CAP

Wetland: MD-WRA, NOAA-C-CAP
Upland: FWS-NWI

Wetland: NOAA-C-CAP
Upland: FWS-NWI, MD-WRA

Wetland: FWS-NWI
Upland: MD-WRA, NOAA-C-CAP

Wetland: MD-WRA
Upland: FWS-NWI, NOAA-C-CAP

Upland: FWS-NWI, MD-WRA, NOAA-C-CAP

Wetland: NRCS-WI

Field Evaluation: ● Wetland ⊗ Transitional o Upland o* Drained

Figure 18 **Scale 1:9,600**

Transect H

11 miles - Vienna
27 miles - Cambridge

4.5 miles - Salisbury
35 miles - Ocean City

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 19. **Scale 1:10,087**

Wetland Data Set Comparison
Transect H

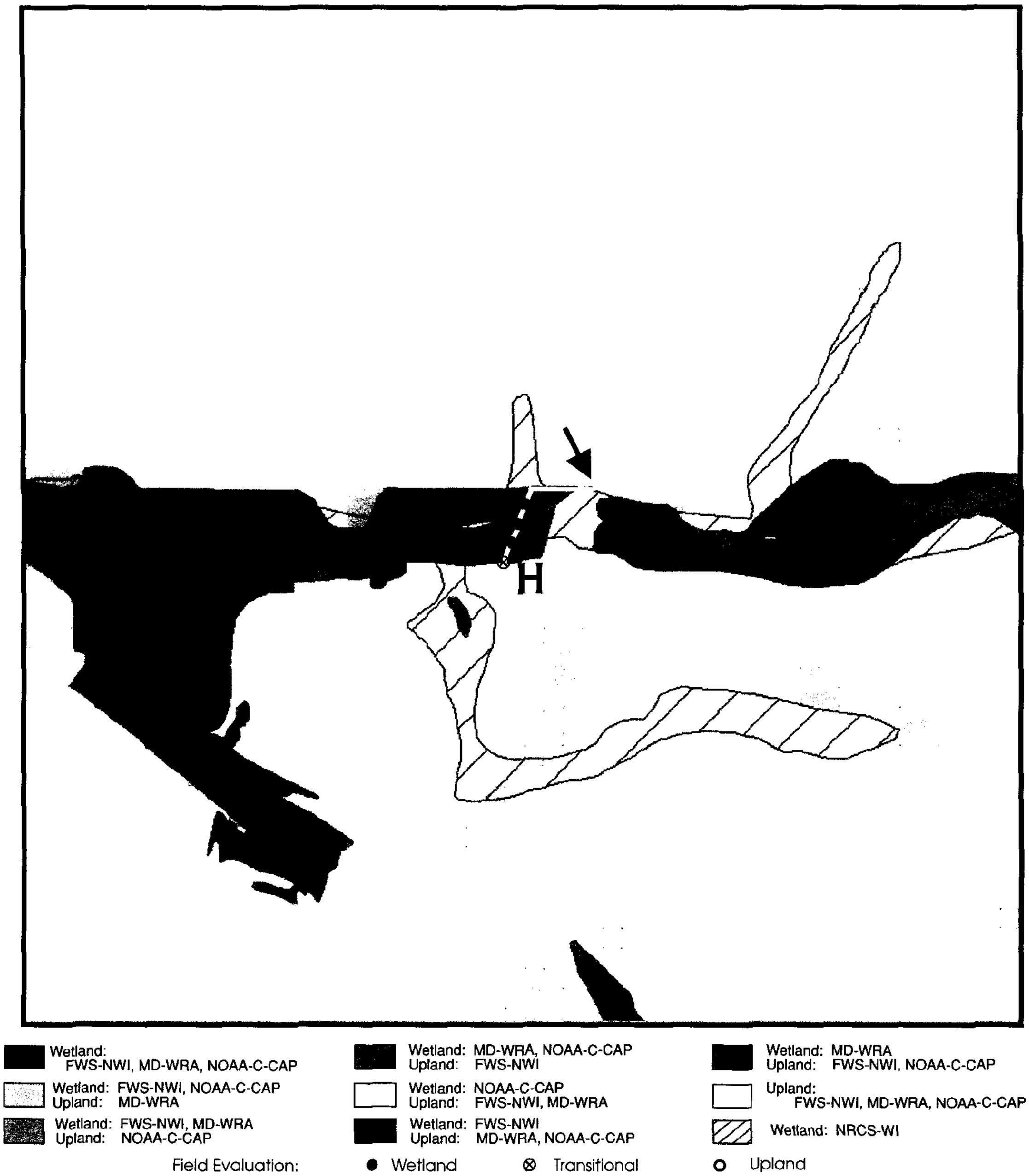


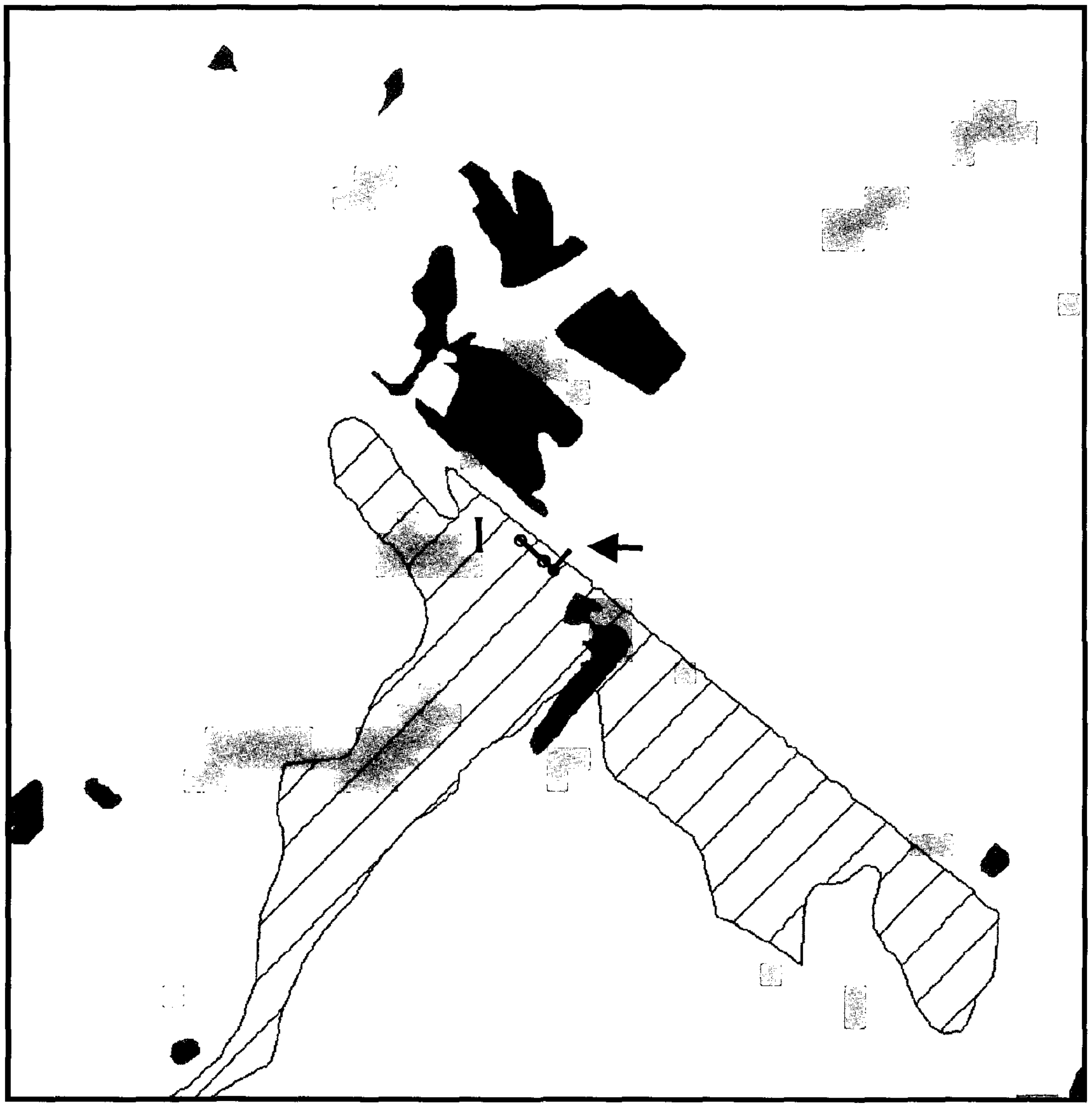
Figure 20 Scale 1:10,087

Transect I

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 21. **Scale 1:7,680**

Wetland Data Set Comparison
Transect I



- Wetland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: FWS-NWI, NOAA-C-CAP; Upland: MD-WRA
- Wetland: FWS-NWI, MD-WRA; Upland: NOAA-C-CAP
- Wetland: MD-WRA, NOAA-C-CAP; Upland: FWS-NWI
- Wetland: NOAA-C-CAP; Upland: FWS-NWI, MD-WRA
- Wetland: FWS-NWI; Upland: MD-WRA, NOAA-C-CAP
- Wetland: MD-WRA; Upland: FWS-NWI, NOAA-C-CAP
- Upland: FWS-NWI, MD-WRA, NOAA-C-CAP
- Wetland: NRCS-WI

Field Evaluation: ● Wetland ⊗ Transitional o Upland

Figure 22 **Scale 1:7,680**

200 feet. The field data were consistent with the NOAA-C-CAP and NRCS-WI classification of the area as wetlands. Figure 11 and figure 12 allow a comparison of the wetland classifications by the agencies and the physical representation shown by the digital orthophotoquad. Note that the darker areas on the digital orthophotoquad are classified as wetlands by more than one agency.

In figure 12, transect A' is delineated as wetland by NRCS-WI and as upland by FWS-NWI, MD-WRA, and NOAA-C-CAP. It is, however, on the boundary of an area that NOAA-C-CAP classified as wetland. The field team entered from the other side of the road approximately 2,000 feet east of transect A and went into the area 200 feet, taking measurements at 100 and 200 feet. In this case, although the soils were hydric, the field team classified the sites as transitional, meaning that the sites could be classified as either wetland or upland. An accurate wetland determination at these sites can only be made during the wet part of the year, either spring or fall.

Transects B and B' were selected to evaluate several issues. Figure 14 shows the wetlands classifications by the various agencies for transects B and B'. Figure 13 is the digital orthophotoquad for the area surrounding the transects. The transects go through areas that NOAA-C-CAP identified as wetlands alone and that NRCS-WI identified as wetlands alone. The transects also go through an area that all four data sets classified as wetlands. In addition, the transects go through an area that NRCS-WI identified as uplands and some or all of the other agencies identify as wetlands.

The field team entered transect B from Rum Ridge Road at 305 degrees and made measurements every 100 feet for 2,200 feet. The first eight points were identified as wetlands with hydric soils. The FWS-NWI identified all eight of these sites as uplands. The MD-WRA identified three of the eight sites as wetlands. The NOAA-C-CAP and NRCS-WI identified all eight sites as wetlands. Site evaluations at 900 and 1,000 feet showed transitional sites and soils. The FWS-NWI, MD-WRA, and NRCS-WI identified the sites as uplands, and NOAA-C-CAP classified the sites as wetlands. The field team classified the sites at 1,100 and 1,200 feet as upland, nonhydric, which is consistent with identifications by FWS-NWI, MD-WRA,and NRCS-WI. Only

NOAA-C-CAP identified the area as a wetland. Transitional sites were identified by the field team at 1,300 and 1,400 feet, with hydric soils at 1,400 feet. Again, FWS-NWI, MD-WRA, and NRCS-WI classified the sites as uplands, and NOAA-C-CAP classified them as wetlands. Wetlands with hydric soils were identified by the field team at 1,500, 1,600, and 1,700 feet; NOAA-C-CAP classified all of the sites as wetlands; and NRCS-WI classified all of the sites as uplands. The FWS-NWI and MD-WRA classified one and two of the sites, respectively, as wetlands. The field team classified the site at 1,800 feet as upland, nonhydric, with only NOAA-C-CAP disagreeing and identifying it as wetlands. At 1,900 feet, the field team classified the site as wetland and NOAA-C-CAP and NRCS-WI agreed. At the sites for 2,000, 2,100, and 2,200 feet, the NRCS-WI classified the sites as wetlands, but the other agencies all classified the sites as uplands. The field team identified one site as wetland, one as upland, and one as transitional.

Transect B' was entered from the other side of Rum Ridge Road at 125 degrees and field evaluations were made every 100 feet for 800 feet. At 100 feet, the field evaluation was upland with nonhydric soils. The FWS-NWI and MD-WRA data agreed with the evaluation, but NOAA-C-CAP and NRCS-WI data called the site wetland. At 200 feet, the field evaluation determined that the site was a transitional area with hydric soils. The FWS-NWI, MD-WRA, and NOAA-CAP all classified the site as upland, but NRCS-WI classified the site as wetland. The field evaluations at 300 and 400 feet identified the sites as uplands, with hydric soils at 300 feet and nonhydric soils at 400 feet. The MD-WRA agreed with the field evaluation for both sites. The FWS-NWI and NOAA-C-CAP agreed with the upland classification at 300 feet, but classified the site at 400 feet as wetland. The NRCS-WI classified both sites as wetlands. The field evaluations for 500, 600, and 700 feet were all wetlands with hydric soils. This classification was consistent with data from MD-WRA, NOAA-C-CAP, and NRCS-WI. The FWS-NWI agreed with the classifications at 500 and 600 feet, but classified the site at 700 feet as upland. The field team classified the site at 800 feet as upland with nonhydric soils, agreeing with FWS-NWI and MD-WRA data. The NOAA-C-CAP and NRCS-WI classified the site as wetland.

Transects C and C', shown in figures 15 and 16, are areas that NOAA-C-CAP classified as wetlands, but that FWS-NWI and MD-WRA classified as uplands. The NRCS-WI classified the sites in transect C' and one of the sites in transect C as uplands. The purpose of the evaluation was to examine sites that NOAA-C-CAP had classified as wetlands, but that FWS-NWI and MD-WRA had not. In addition, the selection was based partly on an interest in the effect that NRCS-WI had on the classification.

The field team entered transect C at 200 degrees from Melson Road in the northeast part of the Delmar quadrangle. The first evaluation site was at 100 feet. The field classification indicated that the site was upland with nonhydric soils, which agrees with classifications by FWS-NWI and MD-WRA. The NOAA-C-CAP and NRCS-WI classify the site as wetland. A second field evaluation confirmed the upland classification, but showed hydric soils. Evaluations were also taken 100 feet west and east parallel to Melson Road. The field classifications were upland with nonhydric soils, which agrees with FWS-NWI and MD-WRA classifications. The NOAA-C-CAP classifies both sites as wetlands, but NRCS-WI classifies the site 100 feet west as wetland and the site 100 east as upland.

Transect C' was entered from Melson Road, east of transect C. Three site evaluations were taken and all were upland with nonhydric soils. The first site was 100 feet east on Melson Road and 80 feet in on the south side of the road. The second evaluation was 200 feet east on Melson Road and 80 feet in on the south side of the road. The third site was 300 feet east and in 80 feet on the north side of the road. The FWS-NWI, MD-WRA, and NRCS-WI agree with the site evaluations. The NOAA-C-CAP classifies the sites as wetlands.

Transects D and D' were entered from Rum Ridge Road, about 550 feet southeast from the intersection with Melson Road. Transect D is 100 feet in from the east side of Rum Ridge Road, and transect D' is 100 feet in from the west side of Rum Ridge Road. Both site evaluations were uplands with nonhydric soils. The FWS-NWI and MD-WRA agree with these classifications, NOAA-C-CAP classifies transect D as upland and D' as wetland, and NRCS-FSA classifies both sites as wetlands.

Transect E follows a path off of Fooks Road in the northeast part of the Salisbury quadrangle. The purpose of this evaluation was again to examine sites that NOAA-C-CAP classified as wetlands. The FWS-NWI and MD-WRA each classified three out of four of the sites as uplands, NRCS-WI classified three out of four of the sites as wetlands, and NOAA-C-CAP classified all four sites as wetlands. In fact, the first two sites were classified in the field as transitional with hydric soils, and the last two were identified as uplands with nonhydric soils.

Transect F was also off of Fooks Road in the northeastern part of the Salisbury quadrangle, about 550 feet west of transect E. Transect F was selected because it is an example of a site that MD-WRA identified as a wetland, but that FWS-NWI and NOAA-C-CAP identified as an upland. NRCS-WI also classified the site as wetland. In fact, it was determined during the field test that the site was a transitional site with hydric soils.

Transect G was 2,650 feet west of transect E on Fooks Road in the northeast part of the Salisbury quadrangle. Transect G was selected as an example of a site that NOAA-C-CAP classified as wetland, but that FWS-NWI and MD-WRA classified as upland. NRCS-WI identified the site as wetland. The field evaluation identified the site at 100 feet as a drained wetland with hydric soils and at 200 feet as upland with nonhydric soils.

Transect H, in the southeast part of the Hebron quadrangle, provides an example at 100 feet of a site that MD-WRA classified as wetland, and that FWS-NWI and NOAA-C-CAP identified as upland. The NRCS-WI identified this site as wetland, as did the field evaluation. At 200 feet, all agencies except for NOAA-C-CAP identified the site as wetland, as did the field evaluation. The site at 300 feet is an example where FWS-NWI classifies the site as wetland and MD-WRA and NOAA-C-CAP classify the site as upland. The NRCS-WI and the field evaluation classified the site as wetland with hydric soils. At 400 feet, only FWS-NWI classified the site as wetland. The field evaluation identified the site as transitional with hydric soils. The final transect, I, was entered from Brick Kiln Road in the southeastern part of Hebron quadrangle. The first site, 100 feet off the road, was identified by NRCS-WI as a wetland and by the other agencies as an upland. The field team identified the site as wetland with hydric soils. All agencies classified the site 50 feet northwest and parallel to the road as upland, as did the field team. The NRCS-WI identified the site 150 feet northwest of the first site, parallel to the road, as wetland, but the other organizations classified the site as upland. The field team classified the site as upland with nonhydric soils.

The results of the second field test, summarized in table 14, are consistent with earlier results shown in this paper. The NOAA-C-CAP and NRCS-WI exhibit a greater tendency to classify points as wetlands than do MD-WRA and FWS-NWI. The NOAA-C-CAP and NRCS-WI classify 40 and 39 points, respectively, as wetland in the test sites, and FWS-NWI and MD-WRA classify only 8 and 12, respectively, as wetlands. More detailed data from the second field test are contained in appendix 4.

These results can be interpreted in two ways. Although FWS-NWI and MD-WRA do not identify as many points as wetlands as do NOAA-C-CAP and NRCS-WI, the great majority of the points classified by these data sets were found during the field test to be either wetland or transitional. Seven of the eight points classified as wetland by FWS-NWI were identified as a wetland or as transitional during the field test; for MD-WRA, the ratio is 11 out of 12. Although the proportion is smaller for NOAA-C-CAP and NRCS-WI, it is still greater than half. For NOAA-C-CAP, 23 out of the 40 points classified as wetland were found during the field exam to be wetland or transitional; for NRCS-WI the proportion is 26 out of 39 points.

The second way of interpreting the results is to evaluate the proportion of the wetlands identified during the field test that were classified as wetlands by the various data sets. As would be expected, the data sets with a greater tendency to classify areas as wetlands did classify as wetlands a larger proportion of the points identified during the field test as wetlands. During the field test, 22 points were identified as wetlands. Of these 22 points, NOAA-C-CAP classified 17 of them as wetlands, and NRCS-WI classified 19 of them as wetlands. On the other hand, the data sets that have a smaller tendency to classify areas as wetlands, classified as wetlands a smaller proportion of the points identified during the field test as wetlands. Of the 22 points identified as

Table 14. Wetland Data Comparison — Second Field Test/Wetland Data Sets (Points)

[Shaded areas represent agreement between the data set and the field test results. A single point in the field test (transect G) was found to have been drained. The results from that point are not included in this table.]

		Field Test			
		Wetlands	**Uplands**	**Transi-tional**	**Totals**
FWS-NWI	**Wetlands**	5	1	2	8
	Uplands	17	21	10	48
	Totals	22	22	12	56
MD-WRA	**Wetlands**	10	1	1	12
	Uplands	12	21	11	44
	Totals	22	22	12	56
NOAA-C-CAP	**Wetlands**	17	17	6	40
	Uplands	5	5	6	16
	Totals	22	22	12	56
NRCS-WI	**Wetlands**	19	13	7	39
	Uplands	3	9	5	17
	Totals	22	22	12	56

wetlands during the field test, FWS-NWI classified only 5 as wetlands, and MD-WRA classified 10 as wetlands.

It should be pointed out that 12 of the 56 points evaluated on the transects were found to be transitional; that is, the field team could not make a positive determination of whether the point represented a wetland or an upland. The fact that a positive determination could not be made on the ground in more than 20 percent of the points evaluated underscores the fact that the study team selected transects in areas where the data sets were inconsistent in wetland delineation and where difficulties in interpretation were expected.

Conclusions and Future Plans

V. Conclusions and Future Plans

A. Conclusions

The results of the case study in Wicomico County, Md., support two principal hypotheses: (1) there is significant disagreement in wetland delineation among the various government wetland data sets; and (2) there are substantial differences in the strengths and weaknesses of the wetland data sets evaluated. These strengths and weaknesses relate to the effectiveness of the data sets in identifying all wetland areas as wetlands, and (or) in delineating only wetland areas as wetlands. The results reported in this paper are derived from a case study in one county; additional data and analysis are required to evaluate these hypotheses conclusively. That is, the issues raised in this case study merit attention and analysis beyond Wicomico County.

1. Data Inconsistency

The four data sets with polygon data, FWS-NWI, MD-WRA, NOAA-C-CAP, and NRCS-WI, disagree in wetland delineation in almost 40 percent of the study area. In areas that at least one of the four data sets delineates as wetland, there is disagreement among the data sets in more than 90 percent of the area. This disagreement is not just among wetland classes or systems, but rather on the fundamental question of whether or not an area is a wetland.

NRCS-WI accounts for more than 70 percent of the area that only one of the four data sets delineates as wetland. This is not surprising because data for the NRCS-WI are collected for regulatory purposes and are designed not to miss possible wetland areas. When the three other data sets with polygon data are compared, they continue to disagree among themselves in about 80 percent of the area that at least one of the three data sets delineates as wetland. In fact, in comparisons between any two of the data sets with polygon data, there is disagreement in more than 50 percent of the area that at least one of the two data sets delineates as wetland. Again, this disagreement is not among wetland classes or systems, but rather on whether or not an area is a wetland.

Comparisons between NRCS-NRI, which has point data, and the four data sets with polygon data produce similar results. In these comparisons, there is disagreement in more than 99 percent (103 out of 104) of the points that are classified by at least one data set as wetland.

There are several possible explanations for this high level of disagreement or inconsistency among the data sets. First, it should be emphasized that the results presented in this analysis represent data from just one county. A distinguishing factor in Wicomico County, Md., is that a high proportion of the wetlands are palustrine forested.[41] Previous studies have noted the difficulty in using remote sensing techniques to identify wetlands in forested areas. In fact, more than half of the palustrine wetlands delineated by FWS-NWI and MD-WRA are further delineated in these data sets as evergreen forested wetlands and temporarily flooded deciduous forested wetlands, two of the subclasses identified by Tiner (1990) as among the most difficult to photointerpret.

The results of the analysis show that a large proportion of the disagreement among the data sets occurs in areas that at least one data set classifies as palustrine wetland. Significantly, this disagreement occurs even between data from FWS-NWI and MD-WRA, which use identical classification systems and similar aerial photography photointerpretation techniques.[42]

It is also significant that most of the disagreement occurs in areas that at least one data set classifies as palustrine, and the level of agreement among data sets is much greater for wetland types other than palustrine. For instance, more than 90 percent of the areas classified as lacustrine, riverine, or estuarine wetlands by FWS-NWI are also classified as wetlands by MD-WRA. The percentage of the area classified as lacustrine, riverine, or estuarine by MD-WRA that is also classified as wetland by FWS-NWI is almost as high.

[41]Three of the data sets with polygon data, FWS-NWI, MD-WRA, and NOAA-C-CAP, distinguished palustrine wetlands from other wetlands. All of the three data sets classified more than 80 percent of the wetlands that they had delineated, as palustrine. The FWS-NWI and MD-WRA classified wetlands to the Cowardin and others (1979) class level and delineated more than 80 percent of the palustrine wetlands as forested.

[42]Subsequent to this analysis, FWS-NWI has updated data for four of the 7.5-minute quadrangles within the study area.

Much of the disagreement among the data sets may be related to problems with the spatial accuracy of the data. When 50-meter buffers are created around the NRCS-NRI points that are delineated by at least one of the data sets as wetlands, the level of agreement potentially rises from less than 1 percent to approximately 41 percent. This implies that there may be problems with the spatial registration of the data in some or all of the data sets. It should be emphasized, however, that even with these 50-meter buffers, there is still disagreement among the five data sets at almost 60 percent of the points that had been delineated by at least one data set as wetland.

There was ambiguity in the wetland delineation in some forested areas even during the field tests. This ambiguity was compounded by the fact that, in many cases, clear changes that would affect the wetland delineation were noted within relatively short distances from the site examined. In the first field test, in more than half of the 130 points examined, boundary changes in wetland delineation were noted within 50 meters of the test point.

The difficulties in identifying palustrine forested wetlands that were demonstrated in this case study raise the question of whether a new category of wetlands that encompasses mixed wetland and upland areas would be helpful in understanding the characteristics and ambiguities in some of these areas. Such a category of wetlands could reduce the level of inconsistency among wetland data sets because larger parcels of land could be classified as mixed wetland and upland areas without the need to distinguish explicitly where small interspersed wetland and upland areas begin and end.

2. Data Set Strengths and Weaknesses

Errors in the delineation of wetlands can be classified into two distinct categories: Type I errors, or errors of omission, and type II errors, or errors of commission. Type I errors occur when a wetland is delineated in a data set as an upland. Type II errors occur when an upland is delineated as a wetland.

The results from the field tests provide evidence (but not statistically significant evidence) that in the study area, FWS-NWI and MD-WRA are more conservative in delineating wetlands than are NRCS-WI and NOAA-C-CAP, and are more likely to commit type I errors, or errors of omission. The results also show that in the field tests, NRCS-WI and NOAA-C-CAP delineate more area as wetlands and commit more type II errors, or errors of commission.

Information on the type of error that is likely to be associated with a particular wetland data set is important both for interpreting wetland data and for improving the effectiveness of data collection efforts. By knowing the type of error associated with a particular data set, users can choose the data set that best suits their needs. Such choices can be based on whether it is more important to identify every wetland area or to know that wetlands delineated are actually wetlands.

B. Future Plans

The case study described in this analysis is part of an ongoing effort by the FGDC Wetlands Subcommittee to implement a strategy to improve the coordination of government wetland data collection and to evaluate whether changes in data collection techniques and responsibilities can improve the government's ability to meet national needs. The strategy contains four sequentially ordered tasks.

Task 1 involves integrating terminology, definitions, and classification systems used by government organizations collecting wetland data. Task 2 involves coordinating government wetland data collection processes and reports. Both tasks 1 and 2 were completed in September 1992.

The case study in Wicomico County, is the first of up to 10 case studies to be studied in task 3A to evaluate the consistency of wetland data collected by various government organizations. The working group began a wetland data set comparison in Logan County, N. Dak., during the summer of 1994. This effort builds upon the work begun in Wicomico County and attempts to deal with similar issues. An additional data set comparison is scheduled to be started in Dade County, Fla., during 1995.

The implementation of task 3B and task 4 will also begin during 1995. Task 3B concerns the consistency of wetland statistical results and includes the development of a crosswalk between the results developed by the various government organizations reporting on wetland status and trends. Task 4 builds on the results from the first three tasks and includes an evaluation of the feasibility and the public policy implications of wetland data integration. This evaluation is expected to study the benefits and costs associated with various levels of wetland data accuracy and timeliness so that these factors can be incorporated into a comprehensive national strategy for wetland data collection.

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Acronym List

Acronym List

C-CAP	——	Coastal Change Analysis Program
CIR	——	color infrared
DOQQ	——	digital color orthophoto quarter quadrangle
EMAP	——	Environmental Monitoring and Assessment Program
EPA	——	Environmental Protection Agency
FACTA	——	Food, Agriculture, Conservation and Trade Act
FGDC	——	Federal Geographic Data Committee
FSA	——	Food Security Act of 1985
FWS	——	U.S. Fish and Wildlife Service
GIS	——	geographic information system
LUDA	——	Land Use Data Analysis Program
MAC	——	Mapping Applications Center
MD-WRA	——	State of Maryland's Water Resources Administration
MOA	——	Memorandum of Agreement
NAPP	——	National Aerial Photography Program
NHAP	——	National High Altitude Photography
NOAA	——	National Oceanic and Atmospheric Administration
NRCS	——	Natural Resource Conservation Service
NRI	——	National Resources Inventory
NWDS	——	National Wetlands Data System
NWI	——	National Wetlands Inventory Program
SAT	——	Status and Trends Report
SCS	——	Soil Conservation Service
USDA	——	U.S. Department of Agriculture
USGS	——	U.S. Geological Survey
WI	——	Wetland Inventory
WSSC	——	Wetlands of Special State Concern

Appendix 1

Wetland Data Set Descriptions

Appendix 1 — Data Set Descriptions

Appendix 1 contains descriptions of Federal and State Government wetland data sets available in Wicomico County. The descriptions were supplied by the organizations responsible for the data sets. The data sets and agencies are:

National Wetlands Inventory — U.S. Fish and Wildlife Service

National Wetlands Inventory, Wetland Status and Trends — U.S. Fish and Wildlife Service

Digital Orthophoto Quarter Quadrangle and Wetlands Mapping Programs — Water Resources Administration, State of Maryland

Environmental Monitoring and Assessment Program — U.S. Environmental Protection Agency

National Resources Inventory — Natural Resources Conservation Service (formerly Soil Conservation Service)

Wetland Inventory Maps -- Natural Resources Conservation Service

Coastal Ocean Program, Coastal Change Analysis Program — National Oceanic and Atmospheric Administration

Land Use Data Analysis Program — U.S. Geological Survey

A. U.S. Fish and Wildlife Service — The National Wetlands Inventory

Remote Sensing the Nation's Wetlands

1. Authorization

The Emergency Wetlands Resources Act of 1986 (as amended), which provides the strongest mandate among other authorizing legislation, requires the Fish and Wildlife Service to produce wetland maps for Alaska by September 30, 1998, to produce maps for noncontiguous areas by 2000, to digitize the wetland maps by 2004, to update the status and trends report at 10 year intervals, to archive the wetland information, and to disseminate wetland information as it becomes available.

2. Introduction

The Fish and Wildlife Service (Service) has a major responsibility for the protection and proper management of fish and wildlife and their habitats. The Service has always recognized the importance of wetlands to waterfowl and other migratory birds. From 10 to 12 million ducks breed annually and millions more over winter in the wetlands of the United States. In 1954, the Service conducted a national survey of wetlands it deemed important to waterfowl. Covering only 40 percent of the lower 48 States, it was not a comprehensive resource inventory by today's standards, but the resulting report, "Wetlands of the United States" (Shaw and Fredine, 1956) did begin to focus attention on the importance of wetlands to waterfowl. Since this survey, wetlands have undergone many changes, both natural and man-induced. These changes, coupled with our increased understanding of wetland functions and values, led to the establishment of the National Wetlands Inventory Project.

The goal of the National Wetlands Inventory (NWI) is to develop and disseminate biologically sound scientific information on the characteristics and extent of the Nation's wetland resources. It is our purpose to supply data to policy makers, planners, land managers, and the public so they can make informed decisions that will result in the wise use and management of the resources. We have found that two types of information are needed: (1) detailed maps and (2) status and trends reports.

Detailed wetland maps are needed to assess the impact of site-specific projects and to provide baseline data against which the effects of future policies and activities can be assessed. These maps serve a purpose similar to the Natural Resources Conservation Service's (NRCS) soil survey maps and the U.S. Geological Survey's (USGS) topographic maps. Detailed wetland maps are used by local, State, and Federal agencies, private industry, and other organizations for many purposes, including comprehensive resource management plans, environmental impact assessments, facility and corridor siting, oil spill contingency plans, natural resource inventories, and habitat surveys. National estimates of the current status and trends (that is, losses and gains) of wetlands are needed to evaluate the effectiveness of existing Federal programs and policies, to identify national or regional problems, and to increase public awareness of wetland issues.

3. Preoperational Phase

Before beginning wetlands mapping in 1979, the NWI reviewed existing State and local wetland inventories and existing classification schemes to determine the best approach to inventory wetlands. A remote sensing technique was then selected.

Review of Existing Wetland Surveys

The first step of the preoperational phase was to review existing wetland inventories. The NWI consulted with Federal and State agencies to learn (1) where and when wetland surveys were previously completed, (2) what inventory techniques were used, (3) where to obtain copies of wetland maps that may have been produced, and (4) the status of State wetland map production. Only a handful of States had conducted a wetland inventory, and most of these inventories were restricted to the coastal zone (U.S. Department of the Interior, 1976).

Developing a Classification System

Before beginning the inventory, the Service had to decide how to classify wetlands. In 1975, the Service brought together 15 of the country's top wetland scientists to evaluate the utility of using existing wetland classification schemes for a national inventory. They determined that all existing schemes were too regional in nature and that a new classification system needed to be developed. It was also determined that the classification system should be ecologically based rather than developed for application with a particular sensor or method of inventory. Conventions would be developed to apply the classification with particular methods of inventory.

The Service's wetland classification system (Cowardin and others, 1979) was developed by a team of wetland ecologists, assisted by local, State, and Federal agencies, as well as many private groups and individuals. It went through four major revisions and extensive field testing before its official adoption by the Service on October 1, 1980. The classification system presents a method for grouping ecologically similar wetlands. It is hierarchical, with wetlands divided among five major systems at the broadest level: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. Each System is further subdivided by Subsystems that reflect hydrologic condition; for example, subtidal versus intertidal in the Marine and Estuarine Systems. Below Subsystem is the Class level, which describes the wetland vegetation or, in the case of unvegetated wetlands, its substrate. Each Class is further divided into Subclasses. The classification also includes modifiers to describe hydrology (water regime), water chemistry (pH, salinity, and halinity) and special modifiers relating to man's activity (for example, impounded, partially drained, farmed, artificial).

Organizational Structure

The Service's NWI is staffed by a small group of biologists and cartographers assembled into two groups: NWI Central Control Group and Regional Wetland Coordinators. The NWI Central Control Group, in St. Petersburg, Florida, is the focal point for all operational activities. It acquires all materials necessary for performing the Inventory, provides technical assistance and work materials to the Regional Coordinators, and produces the wetland maps. A service support contractor carries out most of the photointerpretation (some work is contracted out to Service-trained resource agencies or universities) and map production activities with a contract staff of approximately 150 professionals and technicians. All photointerpreters have degrees in the biological or natural sciences and receive extensive training in wetland ecology, classification, and delineation.

Regional Wetland Coordinators, located in the Service's seven regional offices, are responsible for inventorying wetlands within their region and ensuring that all NWI products meet regional needs. They manage contracts for photointerpretation, coordinate interagency review of draft maps, secure cooperative funding from other agencies, and provide training in the use of NWI products.

4. Selecting a Remote Sensing Tool

Remote sensing, combined with the necessary field work, is the obvious method of choice for conducting any nationwide resource inventory. In 1979, when the NWI began operational mapping, the tools most frequently used for resource inventory were Landsat Multi-Spectral Scanner data and aerial photography. After comparing the wetland information needs of the Service and other agencies to the capabilities of both aerial photography and satellite imagery, we found that Landsat would not provide the needed data for classification detail and wetland determinations within the required level of accuracy. We also found that the delineation and classification of wetlands, from any remotely sensed data source, requires more than the measurement or observation of spectral reflectance or signature. In the case of wetlands, the important properties or image characteristics that permit the accurate location, delineation, and classification of wetlands are parallax, tone or color, landscape position, pattern, texture, association, shape, and size.

Using all these image properties and integrating them through the eyes and minds of trained wetland biologists/photointerpreters, who can relate what is seen on the photograph to what they have experienced on the ground, has proved a successful method for the NWI.

In selecting aerial photography for use in the inventory, NWI found it necessary to strike a balance between cost and detail. Our first and most obvious decision was to use only existing metric aerial photographs. Our budget simply would not permit us the luxury of acquiring new photographs. Second, a decision was made to use fairly small-scale metric aerial photographs. The cost of acquiring, managing, handling, and storing large-scale photographs was prohibitive. For example, the number of photographs required to provide stereo coverage of a 1:100,000-scale map area (0.5 degree of latitude by 1 degree of longitude) at a scale of 1:24,000 is 630, but at a scale of 1:80,000 the number is reduced to 84 frames.

When the inventory began mapping, the best high-altitude metric aerial photographs available for large parts of the country were 1:80,000-scale black-and-white panchromatic photographs acquired by the USGS for topographic mapping and producing orthophotoquads.

This was the principal data source for the NWI from 1975 through the early 1980's. In 1980, the USGS began the National High-Altitude Photography Program (NHAP), which acquired 1:58,000-scale color infrared photographs for the country. Although NHAP is no longer in operation, photographs acquired under this program were and are being used for almost all NWI mapping work. In addition, the NWI, through an agreement with the National Aeronautical and Space Administration (NASA), has acquired 1:60,000-scale color infrared photographs of the Prairie Pothole Region of the northern Great Plains. Our experience has shown that the larger scale and color infrared emulsion have allowed more accurate delineation of wetland boundaries, identification of smaller wetland areas, and improved classification of wetland types. The minimum mapping unit for most wetland types is now in the range of 0.5-1.2 hectares (1-3 acres), although for ponds and pothole marshes it is considerably less than 0.5 hectares (Tiner, 1990).

In 1987 NHAP was replaced with the National Aerial Photography Program (NAPP), which is acquiring 1:40,000-scale aerial photographs. This scale has increased the cost of acquiring, managing, handling, and storing photographs. It requires 10 photographs to provide stereo coverage of a

1:24,000-scale map with 1:40,000-scale photography in comparison to NHAP photography, which only requires 3 1:58,000-scale photographs.

Leaf-off, color infrared, 1:40,000-scale NAPP photographs allow the identification of smaller wetlands. Under the best conditions, wetlands as small as 0.1 hectare (0.25 acres) can be identified. This type of photography allows the photointerpreters to make more internal cover type breaks within polygons. The problem is that many of these internal breaks cannot be displayed at a map scale of 1:24,000. Some of the NAPP photographs are leaf-on, making them nearly useless for wetland photointerpretation. Many of the NAPP photographs are black-and-white panchromatic, which increases the difficulty of wetland interpretation.

The NWI has found 1:56,000-scale to 1:60,000-scale color infrared, leaves-off, aerial photographs, taken in the spring or fall, to be the best images for producing wetland maps at a scale of 1:24,000. We use positive transparencies because they provide a sharper image and have a better color balance than prints. Color infrared film can record thousands of separable colors, shades, and hues. Film is a remarkably efficient, effective, and durable medium on which to store data.

5. Mapping Process

The following section presents a brief overview of the NWI's mapping procedures, followed by more detailed discussions of matters relating to the photointerpretation of wetlands and quality control procedures.

Overview

The NWI undertakes the following steps in producing wetland maps (Tiner, 1990):

(1) Reviews aerial photographs to identify obvious wetland types and problematic areas (that is, wetland versus upland, and classification questions - cover types, water regimes, and so on).

(2) Selects sites for possible field-checking and layout of a route for a field trip. Identifies specific sites representative of problematic photograph signatures and obvious wetland types, emphasizing the former.

(3) Conducts field work in the study area (usually one or two 1:100,000-scale work areas per week of field work, depending on wetland density and complexity). Collects site-specific data to resolve photointerpretation questions.

(4) Following a field-trip, reviews field sites on aerial photographs in stereo to become familiar with the photograph signatures associated with the diversity of wetlands in the work area.

(5) Performs stereoscopic photointerpretation using at least four-power magnification. Delineates wetland boundaries on photo overlays, classifies each wetland polygon according to the Service's wetland classification system and photointerpretation conventions (U.S. Fish and Wildlife Service, 1990) and consults existing collateral information, such as, soil survey maps, USGS quadrangle sheets, NOAA charts, and previous wetland maps, as needed.

(6) Conducts follow-up field trip, if necessary, to resolve new problems that arose during photointerpretation and then makes necessary revisions to photographic overlays.

(7) Ensures photointerpretation quality control by the Service Support Contractor's Team Leaders and the Regional Wetland Coordinators and national consistency quality control by the Central Control Group in St. Petersburg, Fla.

(8) Prepares draft large-scale wetland maps (1:24,000 scale for most of the United States, and 1:63,360 scale for Alaska).

(9) Coordinates interagency (Federal and State) review of draft maps and conducts field checking.

(10) Prepares an edited draft map for final map production.

(11) Produces final map.

Photointerpretation of Wetlands

The first infrared films were developed during World War II to allow photointerpreters to discriminate between camouflage and natural foliage. The military called this new film "camouflage detection film." The most important properties of stereoscopic color infrared images for distinguishing wetlands are parallax, color, texture, and pattern. The characteristics of color, texture, pattern, and height are all functions of vegetative life forms. A combination of factors, including leaf size, leaf shape, leaf structure, leaf arrangement, branching pattern, height, growth habit, and color produce a specific response or signature on the image.

The identification of upland vegetation can help determine the extent of wetland vegetation. The upland boundary of a wetland is distinguished by a transition from predominantly hydrophytic vegetation to predominantly mesophytic or xerophytic vegetation, a transition from hydric to nonhydric soils, and a transition from areas subject to flooding or saturation during years of normal precipitation to land that is not flooded. Transition is the primary indicator used in differentiating a wetland from the surrounding upland on aerial photographs. On color infrared photographs, the lack of reflectance by water generally results in black and blue-black tones that are very distinctive. Wetlands with canopy openings that contain standing water will exhibit this signature in combination with assorted wetland vegetation signatures. Saturated soils will show on the photograph in darker tones because of the nonreflectance of the soil-water component. Even when wetland basins are dry, the silt, clay, and other fine materials at the bottom of these wetland basins hold more water than upland soils; this results in a distinctive dark color caused by lack of infrared reflectance. The growth pattern typical of upland vegetation will generally contrast with that of the wetland. The growth pattern of vegetation in a wetland is generally denser, more crowded, or more concentrated than of that in the drier upland; it exhibits a higher degree of lushness, vigor, or intensity compared to vegetation in the surrounding upland; and it may undergo a noticeable shift in physiognomy from that which commonly occurs in the upland. Healthy green vegetation absorbs visible light, but reflects infrared radiation and shows up as reddish to magenta hues on color infrared film. Even wheat grown in a dry wetland basin has a distinctive signature, because it is more vigorous, owing to the extra moisture in the basin. Dead and drying crops in flooded wetland basins also have distinctive signatures.

When physiographic position, as viewed in a magnified stereoscopic image, is associated with the above characteristics, wetland location on an aerial photograph becomes more obvious. The outside boundary of a wetland is delineated on the photograph by determining from the signature where the transition takes place between upland and wetland. Some transition zones are abrupt and self-evident, but others are gradual and subtle. These subtle transitions may require ground-truth determinations and correlations back to the photograph to establish at which point on the apparent continuum a subtle change is occurring. This subtle change can then be used as a clue to typify the boundary.

Patterns or repetitions of spatial arrangement of vegetative types provide important clues in identifying wetlands and their water regime. For example, basins that have a semipermanently flooded center often have a seasonally flooded band around the center and a temporarily flooded outer band. Patterns are not restricted to vegetation; they can include drainage patterns, land use patterns, and so on. Patterns of land use can be helpful in wetland photointerpretation. At times, the boundaries of fields are formed by wetlands. Unplanted basins in farm fields often indicate wetlands, as do basins planted to a different crop. Land cover patterns such as ridges and swales also help separate uplands and wetlands.

All NWI photointerpreters have a degree in the biological or natural sciences that gives them the background needed to understand wetland ecology and identify wetland vegetation and soils. They must have the ability to see stereoscopic images. Before beginning work, they are given extensive training in wetland identification, the Service's wetland classification system, and the identification of wetland plants and soils. Most importantly, these photointerpreters work 40 hours a week, 50 weeks a year, developing and maintaining their wetland photointerpretation skills.

Before beginning work in a given area, the photointerpreters conduct ground-referencing field investigations to gain familiarity with the area and resolve problem signatures on the photographs. These initial ground-referencing field investigations are essential because the colors, shades, and hues for the same classes of wetlands are different with each set of color infrared photographs. These differences are due to film types, different flying heights with the same film, seasonal differences in the vegetation, recent precipitation, varying water levels, and so on. The Regional Wetland Coordinators play a critical role in the initial field investigations. These seven people represent nearly 100 years of field experience in identifying wetlands and applying the Fish and Wildlife Service's wetland classification system. They are knowledgeable about local wetland vegetation, local and regional climate, local and regional precipitation patterns, the effect of rain on photographic images in their region, the local growing season, and regional wetland (hydric) soils.

<u>Wetland Annotation</u>

All wetlands are delineated, following detailed written mapping conventions (U.S. Fish and Wildlife Service, 1990), on clear stabalene mylar fastened to the photograph with the fiducials marked for registration purposes. Wetland delineations are made on the overlays using 4x0 or 6x0 penpoints in waterproof black ink. Four-power mirror stereoscopes are used for viewing the photographs. The magnification and stereoimage allow the interpreter to separate trees from shrubs from emergents. The interpreter can see the lay of the land. Because wetlands occupy topographic lows in the landscape, photointerpreters search drainage patterns, topographic lows, and floodplains along the margins of lakes, rivers, and estuaries for wetlands. They look in the shadows of valleys and ravines. They separate shadows from wetlands. Shadows cast by trees onto agricultural fields often look like wetlands.

The aerial photographs prevails as the data source for mapping except where reliable collateral data, such as soil surveys, National Oceanic and Atmospheric Administration nautical charts, or field check information are available. Changes that have taken place since the date of photography are not included. Wetlands are classified and mapped according to their state at maximum vegetational development in an average year and at the average low water level. This means that, where possible, maximum vegetative summer growth should be classified rather than spring high-water conditions.

Photointerpretation of water regimes is a difficult task. The interpreter observes the amount of standing water, if any, visible on the photograph and relates it to the date of photography, type of wetland vegetation, local or regional precipitation patterns, length of growing season, soil types, physiographic position, and knowledge of the area gained from supplemental sources. These variables are synthesized by the photointerpreter during the assignment of a water regime. This collateral information is necessary because the aerial photographs are only able to reflect the wetland condition at one instant in time. However, the photointerpreter must use this photographic signature to assign a water regime that represents how long water will remain in the wetland relative to the length of the growing season. The wetland plant community often is used to identify the correct water regime.

All wetlands indicated on USGS topographic maps are closely checked on the photographs to ensure their possible inclusion as a wetland. Areas indicated as wetland by swamp symbols on these maps are considered wetland unless strong evidence indicates otherwise. Close attention is paid to topographic contour. Many interpretation errors can be avoided if the degree of slope is taken into consideration in areas where upland tones and textures resemble those of a wetland. This is not to say that in some cases wetlands are not found on slopes. Photointerpreters must also consider the ecological aspects of the area in question.

A typical annotation is PEM1Ad: "P" for palustrine, "EM" for emergent, "1" for persistent, "A" for temporarily flooded, and "d" for partially drained/ditched. If a wetland is completely drained, it is considered historic and is not mapped. If a wetland is partially drained and still maintains growth of wetland (hydrophytic) vegetation, it is mapped using the special modifier "d" for partially drained/ditched.

Quality Control

We have found that quality control depends on the selection and adequate training of the photointerpreters. They need to work as photointerpreters full time to develop and maintain their skills. Photointerpretation quality control starts with a complete review of all work by the service support contractor's quality control staff. Once the work is released by the contractor, it is sent to the appropriate Regional Wetland Coordinator, who reviews every photograph for possible additions, deletions, or misclassifications. Unless extensive corrections are required, the region makes any necessary changes. The photographs are then sent to the NWI Central Control Group for national consistency quality control. Here, a spot-check of photographs is done to insure compliance with national standards for classification and delineation; that consistency is maintained from region to region. It is important to have a sufficient volume of work so that separate quality control staffs can be maintained at the contractor, regional, and national levels. Following these procedures, the NWI has been able to maintain a high degree of accuracy.

An evaluation of NWI maps in Massachusetts has shown that the maps had an accuracy of 95 percent at differentiating wetlands from uplands (Swartwout and others, 1981). This high rate of accuracy has been possible because NWI procedures involve a combination of field work, photointerpretation, use of collateral data, quality control procedures, and good quality aerial photographs.

6. Data Limitations

Because map products have limitations, the following "Special Note" has appeared on all 1.6 million copies of the National Wetlands Inventory Maps.

Special Note

This document was prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with

"Classification of Wetlands and Deepwater Habitats of the United States" (FWS/OBS - 79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in a revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on this document.

Federal, State and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, State or local government or to establish the geographical scope of the regulatory programs of government agencies. **Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, State or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.**

7. Conclusions

The NWI feels that it is meeting its goal of producing high quality, biologically sound information on the Nation's wetland resources. We feel that a large part of our success is due to the dedication and knowledge of the photointerpreters and cartographic technicians doing the work, and to the voluntary contributions of the many Federal, State, local, and private sector agencies and organizations who participate in the draft map review process. The NWI continues to evaluate ways of improving and updating our map products and will continue to cooperate with other groups and agencies in evaluating new sensors, techniques, and technologies.

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B. U.S. Fish and Wildlife Service — The National Wetlands Inventory Wetland Status and Trends

The National Wetlands Inventory (NWI) of the Fish and Wildlife Service (Service) plans, directs, coordinates, and monitors the gathering, analysis, dissemination, and evaluation of information relating to the location, quantity, condition, and ecological importance of the Nation's wetlands. The status and trends part of the NWI is collocated with the wetland mapping operations in St. Petersburg, Fla.

The Wetland Status and Trends Study develops and maintains national-level statistics on the status and trends of wetlands in the Nation. This information is needed to provide information to the Congress and the Federal Government for developing or modifying Federal programs and policies regarding wetlands. The Emergency Wetlands Resources Act of 1986 reaffirmed the importance of this information and provided mandates for completing periodic status and trends reports. In recent years, the use of wetland trends information has been institutionalized in discussions or initiatives dealing with wetlands and other resource issues. National legislation and Congressional reports make direct reference to the status and trends data, and both the scientific and governmental communities have intense interest in updated information. More recently, serious discussion of a national "no net loss" wetland policy goal would seem to hinge on obtaining accurate and current status and trends data. This information is used by Federal, State, and local governments and the scientific community, making the status and trends study a highly visible and technically challenging area.

The objective of the Status and Trends Study is to produce comprehensive, statistically valid acreage estimates of the Nation's wetlands. To accomplish this, there are four components to status and trends operations:

A) Continuous monitoring of the Nation's wetland acreage: This involves updating at least 10 percent of the 3,650 national sample plots each year so that estimates of current rates of wetland change can be made at periodic intervals.

This continuous monitoring enables better response to the requirements of the Emergency Wetlands Resources Act of 1986.

B) Intensification studies in high priority areas: The Service has determined that additional information is needed to assess the wetland acreage trends in key regions of the country. Intensification studies involve adding additional sample plots to specified geographic units to yield more accurate, regionalized trend data. So far the Service has identified the coastal zone of the Atlantic and the Gulf, the Great Lakes Watershed, the Lower Mississippi Alluvial Plain, and the Prairie Pothole Region as areas where intensification numbers are needed.

C) Specialized studies in select areas ("hot spots"): This involves intensified examination and analysis to determine wetland changes in discrete geographic areas (usually countywide). These special studies are usually not statistical samples but specific geographic units where wetland changes can be detected and analyzed for the entire study area.

D) Interagency coordination: Determining the status and trends of the Nation's wetlands is a multifaceted, multidisciplined, and sensitive issue. Cooperation with a variety of other Federal and State agencies is necessary and ongoing. Long-term interagency cooperation between the Service and Environmental Protection Agency to monitor wetland changes in quantity (acreage) and quality is underway. Preliminary efforts to coordinate with the Natural Resources Conservation Service and National Oceanic and Atmospheric Administration have also begun.

A number of crosscutting subtasks are related to these component parts of status and trends, including the following: developing acreage projection methods and modeling, ensuring the integrity of statistical design, developing and maintaining data bases, developing GIS's, acquiring and analyzing remotely sensed images, coordinating efforts with the Service's regions and headquarters initiatives, reporting results, and disseminating information.

C. Maryland Water Resources Administration — Digital Orthophoto Quarter Quadrangle and Wetlands Mapping Programs

1. Purpose of Data Collection

The Water Resources Administration (WRA) is an agency of the Maryland Department of Natural Resources that depends on large-scale map products to accomplish its regulatory and management functions. Although they use a variety of map products, WRA personnel generally prefer using image-based maps because they are more useful for locating positions accurately in the field. The digital orthophoto quarter quadrangle (DOQQ) maps will provide one of three base layers for all geographic information system development by Maryland State Government agencies. The WRA is responsible for development and custody of the wetlands and 100-year floodplain thematic data. Other State and local agencies use the data produced by WRA for planning and management purposes.

2. History of Agency Mapping

Maryland has had four distinct wetland mapping programs since the passage of the Tidal Wetlands Protection Act in 1970. The WRA's first effort was in 1971, when it produced approximately 2,200 uncorrected mylar photograph "maps" at a scale of 1:2,400 and annotated them with the tidal wetlands boundary as defined in State statute. These maps are official regulatory documents filed with each county clerk's office. They were subject to a public hearing and promulgation process that required certified mailings to more than 14,000 private property owners. The WRA still processes orders for copies of the blueline maps.

In 1986, an effort was started to develop a digital wetlands map series to replace the 1971 Tidal Wetlands Boundary Maps. Natural color, 1:12,000-scale photographs were taken in 1985 as a cooperative effort between the State, the Army Corps of Engineers, and the U.S. Fish and Wildlife Service. The WRA contracted with the Image Processing and Remote Sensing Center at Salisbury State University to scan the photographs into a computer mapping system, provide new delineations of wetlands, and develop a method to produce hardcopy maps for public use. This program stopped when the Attorney General's Office determined that the public hearing and notification process would cost the State nearly $2 million for property title searches and certified mailings. The projected cost of mapping was only $165,000. The contract was changed to add a research component that would provide future capabilities to the WRA.

A third mapping effort was begun in April 1989 when the Maryland General Assembly passed the Nontidal Wetlands Protection Act. This legislation required the State to produce guidance maps showing the location of nontidal wetlands and Wetlands of Special State Concern (WSSC) that have unique habitat value or contain rare, threatened, or endangered species. The legislature instructed the WRA to make a new series of maps that had an image base and required their delivery in January 1990, a period of nine months. The WRA again contracted with Salisbury State University and developed a plan to produce the maps. In the mid-1980's, the WRA had contracted with the National Wetlands Inventory (NWI) to digitize the NWI data for Maryland. The WRA used the NWI data over SPOT 10-meter panchromatic satellite images to produce the required map series. Maryland's Natural Heritage Program identified the WSSC areas on these maps.

The fourth project involves statewide production of color DOQQ maps. These maps were designed to be a base layer for many GIS mapping efforts in Maryland by the various Federal, State, and local agencies. The immediate purpose of the maps is production of an updated tidal and nontidal wetlands inventory.

3. Data Collection Area

As noted, production of the DOQQ map series and the wetlands thematic data will provide coverage for the entire State. As of August 1993, approximately 30 percent of the State is funded and being completed. An additional 20 percent is not funded, but photographs were obtained and the WRA is collecting adequate control for this area. The WRA expects to complete the base maps for the entire State (950 maps) by the end of 1995.

4. Data Collection Methods and Technical Specifications

Production of the DOQQ base maps is being completed through contract services with Photo Science, Inc., of Gaithersburg, Md. The base maps are generally identical to the federal specifications for DOQQ map production.

The WRA's contractor provides a qualified photointerpreter (PI) to do wetland delineations using conventional stereoscopic analysis of the 1:40,000-scale color infrared (CIR) aerial photographs. The PI follows the conventions of the NWI and augments the delineation with field checks whenever possible. The WRA's contractor does photo-interpretation on a Sokkisha MS-27 mirror stereoscope. This instrument allows the PI to view the aerial photographs in three dimensions by aligning the overlap of consecutive photographs. The PI distinguishes change in elevation and locates depressions and break-lines along stream channels and floodplains. In addition, the PI can distinguish the difference in elevation between trees and shrubs. The PI first looks for low-lying areas in the landscape where wetlands generally occur. He "trains" his eye on "wetland signatures" in the photographs by using advance knowledge of the wetlands obtained from site visits. The "signatures" are complex groupings of texture and color that respectively indicate plant communities and soil moisture. The PI also uses collateral data such as existing wetland maps, soil surveys, topo maps, and other photographs to help in delineations. The final product is a mylar overlay on which the PI has drafted the locations of photoidentifiable wetlands using a precision technical pen (width 6x0 or .13 mm).

The WRA PI is instructed to classify wetlands according to the Cowardin, and others (1979) Classification of Wetlands and Deepwater Habitats of the United States. The WRA has required a conservative approach that relies on an unambiguous signature in the photographs. Some marginal wetlands are missed by using this approach; however, we have more confidence that the delineated wetlands are jurisdictional. The PI field verifies "problematic signatures" and detects the existence of a wetland on the basis of the vegetation, soils, and hydrology. Several sites that have the same signature are visited for consistency. After field investigations have been completed, decisions are made about whether this photo signature indicates a wet condition. These decisions determine the classification of the signature. Periodically throughout the photointerpretation process, this signature is revisited to gain further confidence before final quality control. The minimal mapping unit is one-half acre, although obvious smaller features are mapped.

Linear features such as small stream channels and ditch lines are generally recognized in Maryland as regulated features under two separate statutes. The definition of these regulated areas is being examined and may soon change. In addition, small stream channels or ditches require excessive field verification to determine the presence or absence of jurisdictional wetlands. Therefore, the WRA instructed the PI to concentrate on mapping polygon features instead of minor linear features.

Farmed wetlands were conservatively mapped for the express purpose of locating potential mitigation sites and providing data to the U.S. Fish and Wildlife Service on mapping these features. No effort was made to comprehensively map farmed wetlands or to provide locations of farmed or prior converted wetlands from the Natural Resources Conservation Service (NRCS) Swampbuster data.

The use of soil survey data is limited to an ancillary data set. Some wetland mapping programs allow mapping of all hydric soil areas as potential wetlands. The WRA takes a more conservative approach by using all three parameters of hydrophytic vegetation, hydrology, and hydric soils in an attempt to accurately delineate wetlands according to the 1987 Corps of Engineers manual.

The WRA issues a separate contract to conduct field verification of the PI's work. Approximately five point locations are visited on each map to verify that a wetland exists, to classify it, and to determine if a boundary condition exists nearby.

The contractor collects and records the information required to complete the field data sheet at each site selecting an observation area within the wetland that best represents characteristics of the entire community. Vegetative communities are evaluated by using the percent of areal coverage within a 30-yard radius. The contractor visually estimates dominant species for each stratum (tree, shrub, and herb) that exceeds 50 percent of the total dominance measure (areal coverage), and any additional species making up 20 percent or more of the total dominant measure for that stratum. These species are identified and recorded on the data sheet. The field indicator status for all species is recorded and totaled for an overall vegetative indicator status representing the community.

Inspection of soil characteristics is also necessary at most sites. Within the observation area a hole is dug at least 18 inches deep, or to a depth sufficient to verify the presence of hydric conditions and confirm the soil type as designated by the County Soil Survey of the NRCS. A description of the soil profile is written on the data sheet showing the depth and color of the horizons and mottles. Any unusual conditions or circumstances that may qualify the contractor's findings are added to the notes section of the data sheet. Visible surface signs of hydric conditions (for example, multiple trunks, water-stained leaves, stream channels) are also recorded on the data sheet.

The potential for bias and errors by the contractor is reduced by using blind controls. The photograph provided by the department has the areal extent of the wetland delineated. However, the PI will sometimes change polygons so that they do not exactly mimic the features in the photographs. The Cowardin classification given by the interpreter is omitted from the data supplied to the contractor. Also, one or more sites selected for observation may have been previously field checked by the department. Finally, an area known to have no wetlands may be included in the sites selected for field verification.

The WRA developed unique procedures for vectorizing the photointerpreted wetlands data. The WRA provides NWI with the source photographs, the wetland interpretations drafted on a mylar overlay, and a digital color orthophoto image of the quarter quadrangle. The NWI's contractor converts the interpreted wetlands into a vector file using procedures developed by the WRA that allow the vectors to be fitted to the image at large scale.

The quality assurance of the vector sets is the single most labor-intensive step performed by the WRA in the creation of the DOQQ wetlands maps. A skilled operator spends approximately 1 day working interactively with the computer to do the required quality assurance.

The WRA staff perform the final hardcopy wetland map production. This process is entirely digital and requires no hand drafting or scribing. After map construction is complete, the computer operator instructs the system to create a print file used to print 1:7,200-scale copies of the map on demand. The print file cannot be altered and will provide a consistent product. Maps are printed on a Versatec 44" electrostatic plotter that has a resolution of 400 dots per inch. The production maps are black and white and take approximately 12 minutes to print. If created in color, they take 48 minutes to print, making it difficult to meet production demands.

Distribution of the digital files is accomplished using one format and media type. Currently, the file structure is MIPS.RVF, and the media is Relax ISO standard format erasable optical cartridges formatted on a T130 controller card.

Specifications for Digital Orthophoto Quarter Quadrangle Maps

Source Photography	NAPP or NAPP specification, 1:40,000 scale, CIR, leaf-off
Control	Targeted monuments approximately every 3.75 feet
Digital Elevation Model	Collected every 300 feet, interpreted to 100 feet, ASCII format
Scan Resolution	32 microns (1 pixel = 4 feet on the ground)
Datum	1983 NAD horizontal, 1929 vertical
Projection	Maryland State Plane Coordinate System 1983
Digital Files	3 separate bands, a composite color image, and cartographic overlays in the MIPS.RVF file format

Digital File Size	Each band and the composite image are approximately 28 megabytes
Projected Total Storage	Approximately 130 gigabytes for all data
Production Scale	NMAS at 1:12,000 scale
Hardcopy	1:12,000-scale Mylar for blueline production 1:7,200-scale electrostatic prints of wetland maps

Specifications for Wetland Interpretation

Method	Standard stereoscopic aerial photographic interpretation using NWI classification methods.
Classification System	Cowardin and others, 1979
Vectorization Process	Scan interpreted Mylar overlay; convert to vector; rough fit vector to image; photointerpreter edits every vector in-place; quality assurance and quality control checks; edgematch vectors; create a continuous-coverage file.
Proposed Changes	One-step interpretation and vectorization process using a softcopy system.

5. Limitations of Data

The WRA DOQQ maps are intended to provide guidance on the relative locations of tidal and nontidal wetlands. Precise boundaries of tidal wetlands shall be determined using the official 1971 State Tidal Wetlands Boundary Maps. Precise boundaries of nontidal wetlands shall be determined in the field using methods established in the 1987 Army Corps of Engineers Wetlands Delineation Manual.

The data provided for comparison in this study were a first-generation data set. Because of the work accomplished during this project, and other field work in this region, the WRA has revised its data sets on two occasions. The current data set shows an approximate 20 percent increase in the areal extent of wetlands.

Maryland provided the USGS with DOQQ maps for the study area by using an ERDAS export routine in WRA's MIPS system. The WRA used a two-step process to convert the wetland vector data from the MIPS file structure into ARC/INFO format. Those data were imported by the USGS and reattributed using a custom routine written by the USGS. The data used for the comparison contained some polygons that were incorrectly attributed as upland. They account for some of the discrepancies between data sets, but are insignificant in terms of areal extent when compared to the total acreage.

D. U.S. Environmental Protection Agency — Environmental Monitoring and Assessment Program

The Federal Geographic Data Committee (FGDC) Wetlands Subcommittee obtained draft digital land cover map data for the Salisbury study area from the Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP). These data were not generated to map wetlands specifically or to provide wetlands status and trends information, but rather to provide a general characterization of land cover and land use patterns. For this reason, these data are not being compared to those of the other programs, which are specifically oriented toward wetlands mapping. Below is a brief summary of this EMAP project's objectives and methods and a discussion of the EMAP-Wetlands program's planned use of wetlands maps and status and trends information.

1. The EMAP Chesapeake Bay Watershed Characterization Project

The EMAP Landscape Characterization Program (EMCP-LC) began the Chesapeake Bay Watershed Characterization Project in 1991 as its primary landscape characterization pilot study. The purpose of the project was to map general land cover patterns in the 65,000-square-mile Chesapeake watershed. Using these data, EMAP resource groups would look for associations between land use and land cover patterns and degraded conditions that their field monitoring had detected in the terrestrial and aquatic ecological resources of the watershed. The Chesapeake Bay Liaison Office and the State of Pennsylvania shared the cost of the project, and project staff coordinated their efforts with NOAA Coastal Change Analysis Program, the Global Change Research Program, and others active in the same study area. The EPA's Las Vegas Laboratory managed and carried out the project.

The primary data source was Landsat Thematic Mapper (TM) imagery, which was analyzed through digital image processing, The draft digital data provided to the FGDC Wetlands Subcommittee in January 1993 were not assessed for accuracy, but are now undergoing assessment.

This project was designed to incorporate digitized National Wetlands Inventory (NWI) wetland maps derived from aerial photographs with the

Landsat TM interpretations, but downsizing of EMAP prevented this from being completed. As originally designed, the Landsat TM analysis planned to use growing-season imagery to improve discrimination of upland cover and of differences in categories of woody (forest and scrub-shrub) cover. The project staff then would overlay NWI digital data coverages on the TM imagery to mask out the wetland areas. In a second step, the staff planned to manually update any apparent changes visible on the satellite imagery (for example, conversion to agriculture). The choice of satellite imagery from the leaves-on season reduced the ability of the TM image analysis to detect and discriminate wetlands; this was a conscious trade-off because NWI data would be incorporated in a later step. For this reason, wetland area statistics based only on this draft TM product are artificially low.

Although the wetlands masking step was not funded, the project was able to digitize hundreds of NWI quadrangles that were previously available only as hardcopy maps. The digitized NWI coverage, which involves a substantial part of the Chesapeake watershed, is being maintained as a separate data layer.

2. EMAP-Wetlands Program Use of Wetlands Maps and Status and Trends Data

The EMAP-Wetlands program is one of EMAP's several component resource groups. Basically, each EMAP resource group is responsible for monitoring and assessing status, changes, and trends in indicators of the condition of their resources across broad regions of the country. Information on status and trends in wetland condition (for example, functional integrity of "health") and status and trends in wetland extent (acreage) are of interest to the EMAP-Wetlands program.

The EMAP-Wetlands program relies on the NWI program in two main areas: NWI maps and sources for choosing sampling sites for monitoring wetlands condition, and the NWI status and trends program to provide information on wetland extent. EMAP-Wetlands will not use EMAP characterization data such as the Chesapeake watershed data to estimate status and trends in wetland extent. Characterization data will be used to analyze possible impacts on wetland condition from activities in the surrounding landscape.

E. Natural Resources Conservation Service — National Resources Inventory

The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), as part of its mission, conducts periodic multiresource inventories of the Nation's non-Federal lands. These inventories serve as the Federal Government's principal source of information on the status, condition, and trend of soil, water, and related resources. This work is done as part of the National Resources Inventory (NRI) program.

The NRI is a multiresource inventory based on soils and other resource data collected at 800,000 sample sites located throughout the Nation. NRI's are based on a stratified two-stage area-sampling scheme that permits extrapolation of point samples to totals for various geographic regions. NRI results are used to formulate policy and assist in planning conservation and environmental programs at the national, regional, and local levels.

The NRCS has been involved with inventories of natural resources for nearly 60 years. The earliest efforts were reconnaissance studies--the Soil Erosion Inventory of 1934 and the 1945 Soil and Water Conservation Needs Inventory. The Soil and Water Conservation Needs Inventories of 1958 and 1967 were the agency's first efforts to collect data nationally for scientifically selected sample sites. These and subsequent inventories have been prepared in cooperation with the Statistical Laboratory at Iowa State University and other USDA agencies, and with guidance from several Federal and State agencies.

The present NRCS resources inventory program is a result of the Rural Development Act of 1972, the Soil and Water Resources Conservation Act of 1977, the Food Security Act of 1985, and the Food and Agricultural Trade Act of 1990. The Rural Development Act directed the Secretary of Agriculture to set up an inventory and monitoring program in recognition of the increasing need for soil, water, and related resource data for the following purposes:

- land conservation, use, and development; guidance of community development for balanced rural-urban growth; identification of prime agricultural areas that should be protected; and

- use in protecting the quality of the environment.

The first NRI was developed in 1977, with subsequent NRI's in 1982, 1987, and 1992. A potential cropland study was done in 1975.

Many types of data are collected for the NRI, including soil characteristics and interpretations (such as slope, depth, land capability class, prime farmland, salinity or acidity, and flooding frequency); earth cover (such as trees, shrubs, and grass); land cover and use (such as crop type, grazing, and recreation); erosion (such as sheet, rill, and wind); land treatment (such as conservation tillage, irrigation, and windbreaks); vegetative and other conditions (such as range condition and species, wetlands, and pasture management); conservation treatment needs (such as erosion control, drainage, and brush management); potential for cropland conversion; extent of urban land; habitat diversity; and cover maintained under the Conservation Reserve Program, where applicable. In addition, the NRI is linked to the NRCS's extensive Soil Interpretation Records data base. Data from other sources can be integrated with the NRI, through spatial links, in a geographic information system.

The 1992 NRI is a temporal as well as a spatial record of the Nation's resources. At each sample point, information is available for 3 years--1982, 1987, and 1992. From this time series, changes in land use and resource characteristics can be estimated and analyzed.

Data collection for the 1992 NRI was handled by multidisciplinary data collection teams headed by State resources inventory specialists; they used various remote sensing techniques, particularly photointerpretation. Most 1992 NRI samples were also part of the 1982 inventory and were field visited at that time, but only some were visited for 1992. Field visits were required when suitable images were not available, when specialized (intensive) data had to be collected for certain modules and samples, and when information was needed for quality control and review purposes. State- and area-level data collection teams used case files and other types of ancillary information. They also took advantage of the local knowledge of field office staff. Other features included state-of-the-art data entry software, increased emphasis on training, nationwide georeferencing of all sample-site locations, and a comprehensive quality assurance program. The software contained sophisticated data checking that helped ensure that 1982, 1987, and 1992 measurements were made consistently so that proper trending analyses could be made using the final data base. Data collection began in the fall of 1991 and concluded on June 1, 1993. Data were monitored and reviewed to ensure that they would reflect 1992 growing season conditions.

The purpose of the NRI is to support agricultural and environmental policy development and program implementation. It provides the information needed to accomplish the following tasks:

- Describe the status and trends of natural resources.
- Evaluate the condition of natural resources using environmental and ecological indicators.
- Assess environmental and economic implications of changes in resource use (including expected changes associated with changes in government policies).
- Plan and manage the Nation's conservation programs, such as the conservation reserve, swampbusting, and erosion abatement programs.

The goals of the NRI program can be met only if numerous characteristics and features are analyzed simultaneously to enable proper interpretations and inferences. The NRI facilitates such analytical work by collecting hundreds of data items for each sample site. Currently these sample sites are specific points. As geographic information system and mapping technologies continue to progress, there will be a shift to the collection and use of mapped (polygonal) data items.

The NRI data base is constructed to allow simultaneous examination of relationships among all the features and resources--these include natural characteristics (such as soil) and human-induced characteristics (management of the land), as well as temporal and spatial aspects. Many types of interpretive and diagnostic maps can be produced using the NRI data base. And geographic information systems facilitate spatial analysis by using the NRI in conjunction with numerous other data bases.

One of the conditions or features identified by the NRI is the presence or absence of wetlands. This information is part of the NRI data base because all natural resource and environmental issues must be included when analyzing land and waste management issues. When policy is being developed, data must exist to address those issues and the socioeconomic factors. The NRI has made wetland determinations since 1977, using several classification systems. For the 1977 NRI, it was determined if the sample point was located in an area classified as a type 3 through 20 wetland, according to the Circular 39 classification system. For the 1982 NRI, there were three data items related to wetlands:

(i) Circular 39 classification, with types 1 and 2 also identified;
(ii) Cowardin classification - kind of system; and
(iii) Cowardin classification - vegetative type.

For the 1987 NRI, only the Circular 39 classification was used. A special update in 1991 established trends from 1982 to 1987 to 1991. For the 1992 NRI, the Cowardin classification method has been used. Also, sample sites have been classified according to wetland and exemption categories developed for the 1985 Food Security Act (FSA). The 1992 NRI will allow analysis of changes between 1982 and 1992, relative to the Cowardin classification method. These analyses will be facilitated by the many additional data items contained within the NRI data base (soils properties, land cover, land use, and so on).

F. Natural Resources Conservation Service — Wetland Inventory

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) wetland inventory maps were created to provide the field offices guidance for identifying wetlands in accordance with the 1985 Farm Bill for participants in USDA programs. In Maryland such maps were created for eight counties on the eastern shore.

Delineations on these maps were made in the office using soil survey data as the base. The hydric soils information for the area investigated at the Salisbury workshop was extracted from the Wicomico County Soil Survey, 1970. In addition to soils data, photointerpretive data were also used. Color infrared aerial photographs (flight date 3/28/82), black-and-white infrared photographs (flight year 1989), and color slides (flight years 1987 and 1988) were additional materials used for making the determinations.

The maps were constructed by outlining hydric soil areas on mylar sheets. Mylar reproductions of the soil survey maps were overlaid on mylar reproductions of the U. S. Geological Survey (USGS) maps (both at a scale of 1:15,840 for all counties mapped except Caroline County, which is at a scale of 1:20,000). Using the USGS maps created a more rectified base than the soil survey provided and also designated reference points. The following are brief descriptions of the wetland conventions used.

W Wetland (hydric soils + permanent vegetation, usually wooded)

NW Non-Wetland (no hydric soils present and no wet signature on aerial photographs)

PC Prior Converted Cropland (hydric soil cropped areas that were converted for the purpose of or having the effect of making the production of an agricultural commodity possible before December 23, 1985)

FW Farmed Wetland (hydric soil areas, or soils with hydric inclusions, in cropfields that display a wet signature on the aerial photographs)

As previously stated, these maps were created to serve as a guide for field office staff when making wetland determinations. Because the maps are conservative and may overestimate the acreage of wetlands, each office using these maps was instructed to conduct a field investigation of any sites on which a landowner intends to make any land changes. Because the determinations were made in the office, the maps have limitations in reference to specific delineations (where to draw the line). To find the true transitional lines separating wetland from upland areas, one must conduct a field investigation. The soil surveys also limit the accuracy of the maps because hydric soil inclusions three acres or less in nonhydric map units are not included in the soil surveys. Therefore, smaller wetland areas may not have been identified.

G. National Oceanic and Atmospheric Administration — Coastal Ocean Program Coastal Change Analysis Program

In 1990, the National Oceanic and Atmospheric Administration (NOAA), as part of its Coastal Ocean Program, began the Coastal Change Analysis Program (C-CAP) to monitor coastal wetlands, including submerged aquatic vegetation (SAV), and adjacent upland cover and change in the coastal region of the United States (Ferguson and others, 1993; Ferguson and others, 1992; Thomas and others, 1991; Thomas and Ferguson, 1990). The long-term goal of C-CAP is to determine how land cover and changes in land cover affect living marine resources -- their abundance, distribution, and health. To do this, NOAA plans to develop a comprehensive, nationally standardized information system for land cover and change in the coastal region of the United States, making use of satellite images, aerial photographs, surface level data, and other collateral data within a geographical information system context.

The project is intended to be a cooperative effort with other Federal and State agencies. The first three years of the project have been devoted primarily to developing a standardized protocol that is based on a series of regional workshops and smaller working group meetings held around the country with other Federal, State, and academic personnel (Dobson and others, unpub. data; Haddad, 1992; Dobson and Bright, 1991). Additional research and development is continuing in areas such as accuracy assessment, classification, tidal effects, and modeling. C-CAP is working with the States of Texas, Florida, South Carolina, North Carolina, Massachusetts, New York, New Jersey, Georgia, Louisiana, California, Oregon, Alaska, and Washington, as well as with the Gulf of Maine Program, the Chesapeake Bay Program, the Environmental Monitoring and Assessment Program (EMAP), the U.S. Fish and Wildlife Service National Wetlands Inventory, and academia on these issues.

The coastal region to be covered by C-CAP includes those land and water components of the various watersheds within the United States, its possessions, and territories that most directly influence estuarine and coastal marine habitats used by living marine resources. The land cover includes those classes of vegetation and physical cover of ecological significance to living marine resources and (or) their habitats. The major classes will include water and submerged land, including SAV, wetlands and uplands (Klemas and others, 1993).

Satellite imagery (that is, Landsat Thematic Mapper, SPOT, and follow-on sensors) will be the primary data source for coastal wetlands and adjacent uplands. Aerial photography will be the primary source for determining the abundance and distribution of SAV. The planned time interval for repeated looks at the coastal region of the United States is every 1 to 5 years. Regions with little change or interest will be monitored every 5 years; areas of intense development, every 2 or 3 years; and areas disturbed by extreme events (fore example, oil spills, hurricanes), annually. Data will be collected as synaptically as possible to facilitate change analysis. Additionally, a component of C-CAP is being developed so that not just areal coverage is determined, but also functional health (Patience and Klemas, 1993), whereby a decline in the functioning of a coastal habitat could be observed before its loss in area. This component is being coordinated with the Environmental Protection Agency's Environmental Monitoring and Assessment Program.

The NOAA data used in the interagency comparison (Wicomico County, Md.) were derived from Landsat Thematic Mapper images (spatial resolution of 30 meters). These data were processed by the Geographic Data Systems Section of the Oak Ridge National Laboratory, Oak Ridge, Tenn. Processing was in accordance with the C-CAP Regional Implementation Manual (Dobson and others, 1995).

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H. U.S. Geological Survey — Land Use Data Analysis Program

For comparison with wetland data sets developed by other Federal agencies and by the State of Maryland, the Wetlands Subcommittee of the Federal Geographic Data Committee (FGDC) obtained digital land use and land cover data over the Wicomico County, Md., area that had been collected in the late 1970's. These data, prepared by the Geography Program of the Land Information and Analysis Office, U.S. Geological Survey, were collected under the Land Use Data Analysis (LUDA) Program using the Anderson Land Use and Land Cover Classification System. The source materials were black-and-white National High Altitude Aerial Photography, collected at the 1:80,000 scale. The compilation scale of the mapped data was 1:125,000 and the publication scale was 1:250,000.

Standards for the land use and land cover data were based on the accuracies allowable at the publication scale. The accuracies refer to positional accuracy as well as minimum size criteria for polygon identification. Essentially, the classification system was a two-level hierarchical system. The LUDA data were intended to cover the Nation at a consistent scale. This was the first time a nationwide land use and land cover collection effort had been attempted and completed.

Because the LUDA Program collected general land use and land cover types, including forested and unforested wetlands, comparing the wetland delineations and resulting statistics with those of the National Wetland Inventory (NWI) and the National Resource Inventory (NRI) would not be conclusive.

Land Use and Land Cover Mapping at the USGS

For several reasons the LUDA data are not appropriate for use in the wetlands comparison study. First, the data collected are at too large a scale to compare acreage and to compare conventions for identifying wetland areas. The fact that only two categories of wetlands are identified implies that the classification system used was too general to identify wetlands to the degree that NWI and NRI identify them. Second, the LUDA data managers intended to provide a foundation for State and local organizations and other Federal agencies to expand on the classification system and the land use and land cover delineations. To use the wetlands delineations from the LUDA Program would be similar to comparing generalized data to site specific data. Third, although the primary data source was the same as that used by the NWI, the age of the source materials is very different. The conversion of wetlands to a higher order use would adversely affect the comparison of both data sets. Fourth, positional accuracy was not as important as relational accuracy as borne out by the 1:250,000-scale compilation base. Although the data were recorded at the 1:125,000 scale, the accuracy of the base was no better than 1:250,000. This is a major difference from the 1:24,000-scale base used by the NWI.

For these reasons, comparing LUDA wetland acreage and delineations with the NWI data would not provide meaningful results.

Appendix 2

Wetland Data Set Acreage

Appendix 2 — Wetland Data Set Acreage

The tables in appendix 2 present the acreage delineated as wetlands and uplands for each of the data sets studied in the analysis. The tables show the wetland class, the number of polygons contained within a category, and the area in both square meters and acres.

FWS National Wetlands Inventory Data

NWI data - PALUSTRINE

	Class	Polygons	Square meters	Acreage
	Forested	928	37,459,328	9,256
	Emergent	157	2,542,203	628
	Scrub/Shrub	66	1,796,766	444
	Open water	183	1,343,025	332
	Rock bottom	0	0	0
	Unconsolidated bottom	0	0	0
	Aquatic bed	0	0	0
	Unconsolidated shore	0	0	0
	Moss-Lichen	0	0	0
	No class	0	0	0
Total		1,334	43,141,322	10,660

NWI data - LACUSTRINE

	Class	Polygons	Square meters	Acreage
	Open water	19	2,119,463	524
	Unconsolidated bottom	1	89,794	22
	Rock bottom	0	0	0
	Aquatic bed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	Emergent	0	0	0
	No class	0	0	0
Total		20	2,209,257	546

NWI data - RIVERINE

	Class	Polygons	Square meters	Acreage
	Open water	2	1,411,757	349
	Emergent	21	1,035,098	256
	Rock	0	0	0
	Unconsolidated bottom	0	0	0
	Streambed	0	0	0
	Aquatic bed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	No class	0	0	0
Total		23	2,446,854	605

NWI data - ESTUARINE

	Class	Polygons	Square meters	Acreage
	Emergent	33	3,021,930	747
	Open water	5	1,377,815	340
	Flats	16	350,560	87
	Rock bottom	0	0	0
	Unconsolidated bottom	0	0	0
	Aquatic bed	0	0	0
	Reef	0	0	0
	Streambed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	Shrub/Scrub	0	0	0
	No class	0	0	0
Total		54	4,750,305	1,174

NWI data - UPLAND

	Class	Polygons	Square meters	Acreage
	No class	53	583,603,476	144,208
Total		53	583,603,476	144,208

NWI total acreage = 157,193

Maryland Water Resources Administration Data

WRA data - PALUSTRINE

	Class	Polygons	Square meters	Acreage
	Forested	1,317	49,420,875	12,212
	Scrub/Shrub	258	3,465,409	856
	Emergent	290	2,443,162	604
	Farmed	372	1,342,067	332
	Unconsolidated bottom	394	1,872,112	463
	No class	151	463,627	115
	Open water	0	0	0
	Rock bottom	0	0	0
	Aquatic bed	0	0	0
	Unconsolidated shore	0	0	0
	Moss-Lichen	0	0	0
Total		2,782	59,007,252	14,581

WRA data - LACUSTRINE

	Class	Polygons	Square meters	Acreage
	Unconsolidated bottom	22	2,216,035	548
	Open water	0	0	0
	Rock bottom	0	0	0
	Aquatic bed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	Emergent	0	0	0
	No class	0	0	0
Total		22	2,216,035	548

WRA data - RIVERINE

	Class	Polygons	Square meters	Acreage
	Unconsolidated bottom	19	2,792,135	690
	Emergent	32	660,597	163
	Open water	0	0	0
	Rock	0	0	0
	Streambed	0	0	0
	Aquatic bed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	No class	0	0	0
Total		51	3,452,732	853

WRA data - ESTUARINE

	Class	Polygons	Square meters	Acreage
	Emergent	49	2,815,131	696
	Unconsolidated bottom	14	1,647,985	407
	Scrub/Shrub	7	53,235	13
	Open water	0	0	0
	Rock bottom	0	0	0
	Aquatic bed	0	0	0
	Reef	0	0	0
	Streambed	0	0	0
	Rocky shore	0	0	0
	Unconsolidated shore	0	0	0
	No class	0	0	0
Total		70	4,516,351	1,116

WRA data - UPLAND

	Class	Polygons	Square meters	Acreage
	No class	142	566,775,080	140,050
Total		142	566,775,080	140,050

WRA total acreage = 157,148

WRA data contained several polygons that had no labels. There were 11 such polygons that covered 181,294 square meters or 45 acres. If these polygons are taken into account, the WRA total acreage equals 157,193.

FWS National Wetlands Inventory -- Status and Trends Data*

NWI-SAT data - PALUSTRINE

	Class	Polygons	Square meters	Acreage
	Forested	20	1,112,796	275
	Emergent	9	443,214	110
	Shrub	7	64,282	16
	Unconsolidated bottom	2	2,661	1
	Unconsolidated shore	0	0	0
	Aquatic bed	0	0	0
Total		38	1,622,953	402

NWI-SAT data - LACUSTRINE

	Class	Polygons	Square meters	Acreage
	No class	2	338,835	84
Total		2	338,835	84

NWI-SAT data - RIVERINE

	Class	Polygons	Square meters	Acreage
	No class	1	795,098	196
Total		1	795,098	196

*Status and Trends Data are available for only a subset of the study area.

NWI-SAT data - ESTUARINE

	Class	Polygons	Square meters	Acreage
	Subtidal	0	0	0
	Intertidal emergents	0	0	0
	Intertidal forested/shrub	0	0	0
	Intertidal unconsolidated shore	0	0	0
	Intertidal aquatic bed	0	0	0
Total		0	0	0

NWI-SAT data - UPLAND**

	Class	Polygons	Square meters	Acreage
	Other	15	2,063,471	510
	Urban	7	3,707,621	916
	Agriculture	13	1,473,676	364
	Forested plantations	4	481,422	119
	Rural development	0	0	0
Total		39	7,726,190	1,909

**Upland classes are differentiated from wetland classes

NRCS Wetland Inventory Data

	Category	Polygons	Square meters	Acreage
	Not wet	1,025	334,798,983	82,729
	Wet*	548	207,553,310	51,286
	Prior converted	1,026	69,921,959	17,278
	None	283	23,266,930	5,749
	Farmed wet	99	602,813	149
Total		2,981	636,151,168	157,191

*Areas classified as 'wet' meet certain criteria but require further study to determine their true condition.

NOAA Coastal Change Analysis Program Data

	Class	Polygons	Square meters	Acreage
	Grassland	2,201	183,193,838	45,267
	Forest - deciduous, evergreen, mixed	11,480	179,353,312	44,318
	Palustrine forest	3,771	111,813,480	27,629
	Cropland	2,139	101,061,776	24,972
	Developed land	2,961	37,344,538	9,228
	Mixed shrub/scrub	2,377	10,773,695	2,662
	Estuarine emergent wetland	550	6,454,855	1,595
	Water	96	5,575,784	1,378
	Exposed land	48	541,800	134
	Palustrine emergent wetland	1	900	0
	Tidal flats	13	35,100	9
Total		25,635	635,216,363	157,192

Appendix 3

Wetland Data Set Consistency Matrices

by 7.5-Minute Quadrangle

Appendix 3 — Wetland Data Set Consistency Matrices by 7.5-Minute Quadrangle

The matrices in appendix 3 present information on the amount of agreement and disagreement on wetland classification for various pairs of data sets. These matrices are similar to the matrices in tables 6-11; however, the matrices in appendix 3 present data for each of the individual quadrangles, while tables 6-11 present data for the entire study area.

Table A3-1. Wetland Classification Comparison — Hebron Quadrangle FWS-NWI/MD-WRA (Acres)

[*Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree*]

		FWS-NWI					
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	1,140	1	1	0	1,191	2,333
	Lac	3	13	0	0	3	19
	Riv	0	0	0	0	0	0
	Est	0	0	0	0	0	0
	Upl	594	0	0	0	26,406	27,000
	Total	1,737	14	1	0	27,600	29,352

Table A3-2. Wetland Classification Comparison — Hebron Quadrangle

NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

		NOAA-C-CAP				
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	820	9	9	898	1,736
	Lac	0	2	10	1	13
	Riv	0	1	0	0	1
	Est	0	0	0	0	0
	Upl	2,541	15	7	25,037	27,600
	Total	3,361	27	26	25,936	29,350

Table A3-3. Wetland Classification Comparison — Hebron Quadrangle

NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	906	10	12	1,403	2,331
	Lac	0	4	11	2	17
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	2,456	12	3	24,530	27,001
	Total	3,362	26	26	25,935	29,349

Table A3-4. Wetland Classification Comparison — Hebron Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
NRCS-WI	**NW**	1,084	12	12	18,286	19,394
	Wet	2,251	14	13	5,948	8,226
	PC	23	1	0	1,619	1,643
	FW	0	0	0	8	8
	NC	4	0	0	75	79
	Total	3,362	27	25	25,936	29,350

Table A3-5. Wetland Classification Comparison — Hebron Quadrangle FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	343	0	0	0	19,053	19,396
	Wet	1,383	14	1	0	6,829	8,227
	PC	8	0	0	0	1,634	1,642
	FW	0	0	0	0	9	9
	NC	2	0	0	0	75	77
	Total	1,736	14	1	0	27,600	29,351

Table A3-6. Wetland Classification Comparison — Hebron Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
NRCS-WI	**NW**	661	0	0	0	18,735	19,396
	Wet	1,648	18	0	0	6,560	8,226
	PC	20	0	0	0	1,621	1,641
	FW	0	0	0	0	9	9
	NC	2	0	0	0	75	77
	Total	2,331	18	0	0	27,000	29,349

Table A3-7. Wetland Classification Comparison — Delmar Quadrangle FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	497	1	0	0	698	1,196
	Lac	2	160	0	0	16	178
	Riv	1	0	0	0	5	6
	Est	0	0	0	0	0	0
	Upl	216	15	0	0	22,121	22,352
	Total	716	176	0	0	22,840	23,732

Table A3-8. Wetland Classification Comparison — Delmar Quadrangle

NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	378	25	0	313	716
	Lac	18	27	105	26	176
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	2,761	66	27	19,990	22,844
	Total	3,157	118	132	20,329	23,736

Table A3-9. Wetland Classification Comparison — Delmar Quadrangle

NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	625	31	0	540	1,196
	Lac	16	29	0	23	68
	Riv	4	0	0	2	6
	Est	0	0	0	0	0
	Upl	2,509	59	0	19,746	22,314
	Total	3,154	119	0	20,311	23,584

Table A3-10. Wetland Classification Comparison — Delmar Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
NRCS-WI	NW	1,478	65	48	16,497	18,088
	Wet	1,639	39	23	2,708	4,409
	PC	18	0	0	1,028	1,046
	FW	0	0	0	21	21
	NC	21	14	61	77	173
	Total	3,156	118	132	20,331	23,737

Table A3-11. Wetland Classification Comparison — Delmar Quadrangle FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	205	35	0	0	17,850	18,090
	Wet	504	54	0	0	3,849	4,407
	PC	4	0	0	0	1,042	1,046
	FW	0	0	0	0	22	22
	NC	3	87	0	0	81	171
	Total	716	176	0	0	22,844	23,736

Table A3-12. Wetland Classification Comparison — Delmar Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
NRCS-WI	**NW**	405	42	2	0	17,638	18,087
	Wet	771	51	2	0	3,579	4,403
	PC	15	0	1	0	1,030	1,046
	FW	2	0	0	0	21	23
	NC	3	84	0	0	84	171
	Total	1,196	177	5	0	22,352	23,730

Table A3-13. Wetland Classification Comparison — Pittsville Quadrangle FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	595	0	0	0	1,429	2,024
	Lac	0	37	0	0	3	40
	Riv	0	0	0	0	0	0
	Est	0	0	0	0	0	0
	Upl	467	2	0	0	20,012	20,481
	Total	1,062	39	0	0	21,444	22,545

Table A3-14. Wetland Classification Comparison — Pittsville Quadrangle NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	606	1	2	465	1,074
	Lac	0	4	34	1	39
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	3,456	13	5	17,972	21,446
	Total	4,062	18	41	18,438	22,559

Table A3-15. Wetland Classification Comparison — Pittsville Quadrangle NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	1,177	2	5	839	2,023
	Lac	0	4	33	2	39
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	2,879	11	3	17,586	20,479
	Total	4,056	17	41	18,427	22,541

Table A3-16. Wetland Classification Comparison — Pittsville Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
NRCS-WI	**NW**	980	5	14	4,193	5,192
	Wet	2,155	12	27	4,925	7,119
	PC	197	0	0	6,353	6,550
	FW	0	0	0	59	59
	NC	730	0	1	2,908	3,639
	Total	4,062	17	42	18,438	22,559

Table A3-17. Wetland Classification Comparison — Pittsville Quadrangle FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	147	11	0	0	5,035	5,193
	Wet	614	28	0	0	6,477	7,119
	PC	36	0	0	0	6,514	6,550
	FW	0	0	0	0	59	59
	NC	277	0	0	0	3,362	3,639
	Total	1,074	39	0	0	21,447	22,560

Table A3-18. Wetland Classification Comparison — Pittsville Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	317	11	0	0	4,865	5,193
	Wet	1,353	29	0	0	5,737	7,119
	PC	110	0	0	0	6,441	6,551
	FW	1	0	0	0	58	59
	NC	244	0	0	0	3,380	3,624
	Total	2,025	40	0	0	20,481	22,546

Table A3-19. Wetland Classification Comparison — Eden Quadrangle FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	1,770	31	7	15	1,270	3,093
	Lac	0	39	0	0	4	43
	Riv	173	5	439	41	39	697
	Est	24	0	1	1,044	48	1,117
	Upl	869	15	9	74	21,281	22,248
	Total	2,836	90	456	1,174	22,642	27,198

Table A3-20. Wetland Classification Comparison — Eden Quadrangle NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	1,486	247	15	1,086	2,834
	Lac	4	15	43	28	90
	Riv	4	68	366	19	457
	Est	25	685	347	116	1,173
	Upl	2,625	270	66	19,729	22,649
	Total	4,103	1,285	837	20,978	27,203

Table A3-21. Wetland Classification Comparison — Eden Quadrangle

NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

		NOAA-C-CAP				
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	1,611	140	45	1,296	3,092
	Lac	2	4	26	11	43
	Riv	28	239	378	53	698
	Est	20	652	350	95	1,117
	Upl	2,444	249	39	19,514	22,246
	Total	4,105	1,284	838	20,969	27,196

Table A3-22. Wetland Classification Comparison — Eden Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
NRCS-WI	NW	735	227	40	12,005	13,007
	Wet	3,306	875	155	6,371	10,707
	PC	34	17	2	2,412	2,465
	FW	0	0	0	37	37
	NC	28	166	641	152	987
	Total	4,103	1,285	838	20,977	27,203

Table A3-23. Wetland Classification Comparison — Eden Quadrangle FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	351	14	19	63	12,561	13,008
	Wet	2,410	50	78	682	7,490	10,710
	PC	14	2	0	24	2,425	2,465
	FW	0	0	0	0	36	36
	NC	60	26	358	406	138	988
	Total	2,835	92	455	1,175	22,650	27,207

Table A3-24. Wetland Classification Comparison — Eden Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
NRCS-WI	**NW**	451	7	47	46	12,456	13,007
	Wet	2,565	29	262	646	7,200	10,702
	PC	22	2	0	21	2,420	2,465
	FW	1	0	0	0	36	37
	NC	53	5	389	404	136	987
	Total	3,092	43	698	1,117	22,248	27,198

Table A3-25. Wetland Classification Comparison — Salisbury Quadrangle FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
MD-WRA	Pal	669	0	0	0	793	1,462
	Lac	27	209	0	0	32	268
	Riv	2	0	128	0	17	147
	Est	0	0	0	0	0	0
	Upl	255	17	20	0	26,010	26,302
	Total	953	226	148	0	26,852	28,179

Table A3-26. Wetland Classification Comparison — Salisbury Quadrangle NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
FWS-NWI	**Pal**	512	22	15	405	954
	Lac	5	30	160	30	225
	Riv	4	19	96	28	147
	Est	0	0	0	0	0
	Upl	3,134	83	60	23,578	26,855
	Total	3,655	154	331	24,041	28,181

Table A3-27. Wetland Classification Comparison — Salisbury Quadrangle NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

		NOAA-C-CAP				
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
MD-WRA	**Pal**	752	15	10	686	1,463
	Lac	14	34	172	48	268
	Riv	4	18	92	33	147
	Est	0	0	0	0	0
	Upl	2,884	86	58	23,273	26,301
	Total	3,654	153	332	24,040	28,179

Table A3-28. Wetland Classification Comparison — Salisbury Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
NRCS-WI	**NW**	1,286	85	106	17,813	19,290
	Wet	2,278	40	55	4,649	7,022
	PC	68	0	1	1,429	1,498
	FW	0	0	0	11	11
	NC	12	28	169	141	350
	Total	3,644	146	331	24,043	28,171

Table A3-29. Wetland Classification Comparison — Salisbury Quadrangle FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
	NW	235	91	18	0	18,948	19,292
	Wet	693	42	21	0	6,266	7,022
NRCS-WI	**PC**	5	2	0	0	1,491	1,498
	FW	1	0	0	0	10	11
	NC	19	91	109	0	139	358
	Total	953	226	148	0	26,854	28,181

Table A3-30. Wetland Classification Comparison — Salisbury Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	417	104	17	0	18,754	19,292
	Wet	995	73	26	0	5,928	7,022
	PC	22	2	0	0	1,474	1,498
	FW	1	0	0	0	10	11
	NC	28	90	104	0	137	359
	Total	1,463	269	147	0	26,303	28,182

Table A3-31. Wetland Classification Comparison — Wango Quadrangle FWS-NWI/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; shaded areas represent acreage for each system upon which both data sets agree]

	FWS-NWI						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
MD-WRA	**Pal**	2,543	0	0	0	1,930	4,473
	Lac	0	0	0	0	0	0
	Riv	2	0	0	0	0	2
	Est	0	0	0	0	0	0
	Upl	792	0	0	0	20,875	21,667
	Total	3,337	0	0	0	22,805	26,142

Table A3-32. Wetland Classification Comparison — Wango Quadrangle NOAA-C-CAP/FWS-NWI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

		NOAA-C-CAP				
	System	Pal	Est	OW	Upl	Total
FWS-NWI	Pal	2,822	1	8	514	3,345
	Lac	0	0	0	0	0
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	6,468	1	1	16,343	22,813
	Total	9,290	2	9	16,857	26,158

Table A3-33. Wetland Classification Comparison — Wango Quadrangle NOAA-C-CAP/MD-WRA (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; shaded areas represent acreage for each system upon which both data sets agree]

	NOAA-C-CAP					
	System	Pal	Est	OW	Upl	Total
MD-WRA	Pal	3,534	1	8	918	4,461
	Lac	0	0	0	0	0
	Riv	0	0	0	0	0
	Est	0	0	0	0	0
	Upl	5,737	1	1	15,939	21,678
	Total	9,271	2	9	16,857	26,139

Table A3-34. Wetland Classification Comparison — Wango Quadrangle NOAA-C-CAP/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; OW=Open water; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	NOAA-C-CAP					
	System	**Pal**	**Est**	**OW**	**Upl**	**Total**
NRCS-WI	**NW**	2,370	0	6	5,375	7,751
	Wet	6,618	1	4	7,181	13,804
	PC	221	0	0	3,854	4,075
	FW	0	0	0	11	11
	NC	81	0	0	442	523
	Total	9,290	1	10	16,863	26,164

Table A3-35. Wetland Classification Comparison — Wango Quadrangle

FWS-NWI/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	FWS-NWI						
	System	Pal	Lac	Riv	Est	Upl	Total
NRCS-WI	NW	480	0	0	0	7,269	7,749
	Wet	2,762	0	0	0	11,041	13,803
	PC	36	0	0	0	4,040	4,076
	FW	0	0	0	0	11	11
	NC	67	0	0	0	453	520
	Total	3,345	0	0	0	22,814	26,159

Table A3-36. Wetland Classification Comparison — Wango Quadrangle MD-WRA/NRCS-WI (Acres)

[Pal=Palustrine; Lac=Lacustrine; Riv=Riverine; Est=Estuarine; Upl=Upland; NW=Not wet; Wet=Wetland; PC=Prior converted; FW=Farmed wetland; NC=No classification]

	MD-WRA						
	System	**Pal**	**Lac**	**Riv**	**Est**	**Upl**	**Total**
NRCS-WI	**NW**	752	0	0	0	6,997	7,749
	Wet	3,509	0	2	0	10,275	13,786
	PC	146	0	0	0	3,929	4,075
	FW	1	0	0	0	10	11
	NC	64	0	0	0	456	520
	Total	4,472	0	2	0	21,667	26,141

Appendix 4

Field Test Data

Appendix 4 — Field Test Data

Appendix 4 presents data associated with the two field tests. Tables 1 contains data collected during the first field test, while Table 2 presents a comparison of the results from the first field test with delineations from the various wetland data sets. Table 3 contains data from the second field test.

Explanation of Variables in Table A4-1:

Site -- The numbers representing sites in Tables 1 and 2 are consistent; the same number in both tables represents the same site.

Map -- USGS 7.5 minute quadrangle, by quarter quadrangle.

DeNE - Delmar, NE
DeNW - Delmar, NW
DeSE - Delmar, SE
DeSW - Delmar, SW
EdNE - Eden, NE
EdNW - Eden, NW
EdSE - Eden, SE
EdSW - Eden, SW
HeNE - Hebron, NE
HeNW - Hebron, NW
HeSE - Hebron, SE
HeSW - Hebron, SW
SaNE - Salisbury, NE
SaNW - Salisbury, NW
SaSE - Salisbury, SE
SaSW - Salisbury, SW
PiNE - Pittsville, NE
PiNW - Pittsville, NW
PiSE - Pittsville, SE
PiSW - Pittsville, SW
WaNE - Wango, NE
WaNW - Wango, NW
WaSE - Wango, SE
WaSW - Wango, SW

Veg -- Field identification of vegetation associated with wetlands

Hyd -- Field identification of hydrology associated with wetlands

Soil -- Field identification of soil associated with wetlands

Wet -- Field identification of wetlands

Wet Class -- Wetland classification using Cowardin system

Surv -- Soil type from SCS soil survey

Agree -- Agreement with SCS soil survey

Near -- Site within 50 yards of wetland boundary

Change -- Evidence of land use / land cover change in last 10 years

Explanation of Variables in Table A4-2:

W -- Wetland

NW -- Not Wetland

U -- Upland

P -- Palustrine wetland

E -- Estuarine emergent wetland

R -- Riverine wetland

L -- Lacustrine wetland

PC -- Prior converted

FW -- Farmed wetland

WA -- Water

Field Test 1
Table A4-1

Site	Map	Veg	Hyd	Soil	Wet	Wet Class	Surv	Agree	Near	Change
1	DeSW	F	F	F	F		Ek	T	F	F
2	EdSW	T	T	T	T	PSS1/4A	Fa	T	F	F
4	EdNE	T	T	T	T	PFO1A	KsA	F	T	T
5	EdSW	F	F	T	F		Fs	T	T	F
6	EdNE	F	F	T	F		Fs	T	F	T
7	EdNE	F	T	F	F		Fs	F	T	F
9	SaSW	F	F	T	F		Ek	T	F	F
10	SaNW	F	F	F	F		EpB	T	T	F
11	SaNE	F	F	F	F		Ek	T	F	F
12	SaNE	F	F	F	F		Ek	F	F	F
13	SaNE	F	F	T	F		Em	T	F	F
15	SaSE	F	T	T	T	PEMA	No	F	T	T
16	SaSE	F	F	T	F		Ek	T	F	F
17	SaSW	F	F	T	F		Ek	T	F	F
18	SaSE	T	T	T	T	PEM1E	Ek	T	T	F
19	SaNE	F	F	F	F		Ek	F	F	F
20	SaNE	F	F	T	F		Ek	T	T	F
21	SaNE	F	F	F	F		Ek	F	T	F
22	WaSW	F	F	F	F		Pr	F	T	T
23	WaSW	T	F	F	F		Pr	T	F	F
24	WaSW	T	T	T	T	PFO1C	Ek	T	T	F
25	SaSE	T	T	T	T	PEM1C	Ba	T	F	T
36	WaNW	T	T	T	T	PFO1C	Po	T	T	F
37	WaNW	F	F	F	F		KsB	T	T	T
39	WaNW	F	F	T	F		Fs	T	F	F
44	HeSE	F	F	T	F		MnA	F	T	F
45	HeSW	F	F	F	F		WsB	T	F	F
46	HeSW	T	T	T	T	PFO1E	WsA	F	T	F
48	EdNW	F	F	T	F		Fa	T	T	F
49	SaNW	T	T	T	T	PFO1A/C	EpB	F	T	F
50	DeSE	F	F	F	F		Mm	F	F	F
51	DeSE	T	F	F	F		Ek	T	F	T
52	SaNE	T	T	T	T	PFO1A	Ek	T	F	F
53	WaNW	F	F	T	F		Ba	T	T	T
54	SaNE	F	F	F	F		Mm	T	F	F
55	PiSE	F	F	T	F		Fs	T	F	T
58	WaNE	F	F	F	F		EsB	T	T	F
59	WaNE	T	T	T	T	PEM1E	Pk	T	F	T
61	WaNE	T	T	T	T	PEM1C	Le	T	T	T

Table A4-1 (cont.)

Site	Map	Veg	Hyd	Soil	Wet	Wet Class	Surv	Agree	Near	Change
62	WaNE	F	F	T	F		Po	T	F	F
63	WaNE	T	F	F	F		EsB	T	T	T
64	WaNE	F	F	F	F		Po	F	T	F
65	HeNW	F	F	F	F		Mv	F	T	F
66	HeNW	T	T	T	T	PFO1C	EpB	F	T	F
67	HeNW	T	T	T	T	PFO4C	GcB	T	T	F
68	HeSW	T	F	T	F		Fg	T	F	T
69	HeNE	F	F	T	F		Ea	T	F	F
70	HeNE	F	F	T	F		KsA	F	F	F
71	HeSE	F	T	T	F		Fs	T	T	F
73	DeNW	F	F	T	T	PEM1Af	NoA	F	F	F
74	DeNW	F	F	F	F		NoB	T	T	F
75	DeNW	F	F	F	F		No	T	F	F
77	DeSE	F	F	F	F		MfA	T	F	F
78	DeSE	F	F	F	F		Mf	T	F	F
79	PiNW	F	F	F	F		EpB	T	F	F
85	DeSE	F	F	F	F		Mn	T	F	F
92	PiSE	F	F	F	F		Fs	F	T	F
93	PiNE	F	F	F	F		Pk	T	T	F
96	HeNW	F	F	F	F		Fs	F	T	F
97	HeSW	T	T	T	T	PFO1A	Ot	T	F	F
98	EdNE	F	F	F	F		EsB	T	F	F
101	EdNE	F	F	F	F		NoC	T	T	F
102	EdNE	F	F	F	F		NoC	T	T	F
103	EdNE	F	F	F	F		Fs	F	T	F
106	EdNW	F	T	T	F		Fs	T	F	F
107	EdNW	T	T	T	T	PFO1E	Mv	T	T	F
111	EdSE	F	T	T	T	PUB2Hx	Fs	T	T	F
112	EdSE	F	T	T	T	PUB2Hx	Fs	T	T	F
113	EdSW	T	T	T	T	PFO1A	Pk	T	F	F
114	EdSW	T	T	T	T	PFO1A	Fs	T	T	F
115	EdSW	T	T	T	T	PFO1C	Pt	T	F	F
116	EdSW	F	F	F	F		Fs	F	F	F
117	EdNE	F	T	F	F		DoB	T	F	F
118	EdNE	T	T	T	T	PFO1C	Fs	T	T	F
119	EdNE	F	T	T	F		Pe	T	F	F
120	EdNE	F	F	T	F		Fs	T	T	F
121	EdNE	T	T	T	T	PEM1Af	Ru	T	T	F
122	EdSE	F	T	T	F		Fs	T	F	F
123	EdNW	F	T	T	F		Fa	T	F	F
124	EdNW	F	F	F	F		Fs	F	F	F

Table A4-1 (cont.)

Site	Map	Veg	Hyd	Soil	Wet	Wet Class	Surv	Agree	Near	Change
125	EdNW	F	F	T	F		Fa	T	F	F
126	EdNW	F	F	F	F		Fa	T	T	T
127	SaNW	F	F	F	F		EpB	T	T	F
128	SaNW	T	T	T	T	R2UB2/3H		T	T	F
129	SaSE	F	F	F	F		Ek	T	F	F
130	SaSE	F	T	T	F		Ek	T	F	F
131	WaNW	F	F	F	F		Fs	F	F	F
132	WaNW	T	T	T	T	PFO1/2E	Mu	T	F	F
133	WaNW	F	F	F	F		Po	F	F	F
134	WaNE	F	F	F	F		Pk	F	T	F
135	WaNE	T	T	T	T	PFO1C	Ek	T	T	F
136	DeSE	F	F	T	F		Pr	T	F	T
137	DeSE	T	T	T	T	PFO1C	Ks	F	T	F
138	DeNE	T	T	T	T	PFO1A/C	Em	T	T	F
201	DeNE	T	T	T	T	PFO1A	KeB	F	T	F
202	PiNW	F	F	F	F		KsA	T	F	F
204	WaNW	T	F	F	F		KsA	T	F	F
205	WaNE	F	F	F	F		MfA	T	F	F
211	WaNE	F	F	T	F		EsB	F	F	F
212	EdSE	T	T	T	T	PFO1A	Fs	T	F	F
301	EdNW	F	F	F	F		Fa	T	T	T
302	EdNW	F	F	T	F		Fa	T	F	F
303	EdNW	F	F	F	F		WfA	T	T	F
304	EdNW	F	F	T	F		Fs	T	T	F
305	EdNW	F	T	T	T	PEM1Af,d	Fa	T	T	F
306	EdNE	F	T	T	T	PEM1Af	KsA	F	T	F
307	EdNE	T	T	T	T	POW	Fs	T	T	F
308	EdNW	F	F	F	F		Po	F	F	F
310	EdNE	F	T	T	T	PEM1Af,d	Fs	T	T	F
311	EdNE	F	F	T	F		Ru	T	T	F
312	EdSE	F	F	T	F		Po	T	T	F
313	EdSE	F	F	T	F		Ru	T	F	F
314	DeSE	F	T	T	T	PEM1Af	Ek	T	T	F
315	DeSE	T	T	T	T	PEM1E	Ek	T	T	T
316	DeSE	F	T	T	T	PEM1Cf	Ek	T	T	F
317	DeSE	F	F	F	F		Ek	T	F	F
318	DeSE	T	T	T	T	PEM1Ed,f	Ek	T	T	F
319	WaNW	F	F	T	F		Fs	T	F	F
320	WaSE	F	F	T	F		Pk	T	T	F
321	WaSE	F	T	T	T	PEM1Af	Po	T	T	F
322	WaNE	F	F	F	F		Po	F	T	F

Table A4-1 (cont.)

Site	Map	Veg	Hyd	Soil	Wet	Wet Class	Surv	Agree	Near	Change
323	SaSW	F	F	F	F		Ea	F	T	F
324	SaSE	F	T	T	T	PEM1Ad,f	Ea	T	F	F
325	SaSE	F	F	T	F		Ek	T	T	T
326	SaSE	F	F	T	F		Ek	T	F	T
327	SaSE	F	F	F	F		Ek	T	F	F
328	SaNE	F	F	F	F		Ek	F	F	F
329	HeNW	F	F	T	F		Fs	T	T	F
330	HeSE	F	F	T	F		Pe	T	T	F
331	HeSE	F	F	F	F		Ek	T	F	F

Field Test 1
Table A4-2

Site	NRCS-NRI	NOAA-C-CAP	FWS-NWI	FWS-SAT	MD-WRA	NRCS-WI	Field
1	W	U	U	--	U	W	NW
2	W	U	U	--	U	W	P
3	NW	P	U	--	U	NW	--
4	NW	P	U	--	U	NW	P
5	W	P	U	--	U	W	NW
6	W	U	U	U	U	W	NW
7	W	U	U	P	U	W	NW
8	W	U	U	P	U	W	--
9	W	U	U	--	U	W	NW
10	NW	U	U	--	U	NW	NW
11	W	U	U	--	U	W	NW
12	W	U	U	--	U	W	NW
13	W	U	U	--	U	NW	NW
14	W	U	U	--	U	W	--
15	NW	U	U	--	U	NW	P
16	W	P	U	--	U	W	NW
17	NW	U	U	--	U	W	NW
18	W	U	U	--	U	W	P
19	W	U	U	--	U	W	NW
20	NW	U	U	--	U	W	NW
21	W	U	U	--	U	W	NW
22	W	P	U	--	U	W	NW
23	W	U	U	--	U	W	NW
24	NW	P	U	--	U	PC	P
25	W	U	U	--	U	W	P
26	NW	U	U	--	U	NW	--
27	W	U	U	--	U	NW	--
28	W	P	U	--	U	W	--
29	W	P	P	--	U	W	--
30	W	P	U	--	U	W	--
31	W	P	U	--	U	W	--
32	W	U	U	--	U	W	--
33	W	P	P	--	U	W	--
34	W	U	U	--	U	W	--
35	NW	U	U	--	U	NW	--
36	W	P	U	--	U	W	P
37	NW	P	U	--	U	NW	NW
38	NW	P	P	--	P	NW	--
39	NW	U	U	--	U	NW	NW

Table A4-2 (cont.)

Site	NRCS-NRI	NOAA-C-CAP	FWS-NWI	FWS-SAT	MD-WRA	NRCS-WI	Field
40	W	U	U	--	U	W	--
41	W	P	P	--	P	W	--
42	W	U	U	--	U	W	--
43	W	U	U	--	U	W	--
44	NW	U	U	--	U	NW	NW
45	W	U	U	--	U	NW	NW
46	W	U	U	--	P	NW	P
47	W	U	U	--	U	W	--
48	W	U	U	--	U	NW	NW
49	W	U	U	--	U	W	P
50	W	U	U	--	U	NW	NW
51	W	P	U	--	U	W	NW
52	W	U	U	--	U	NW	P
53	NW	U	U	--	U	PC	NW
54	NW	U	U	--	U	NW	NW
55	NW	U	U	--	U	W	NW
56	W	U	U	--	U	NW	--
57	W	U	U	--	U	W	--
58	NW	U	U	--	U	W	NW
59	W	U	U	--	U	W	P
60	W	P	U	--	U	W	--
61	W	U	U	--	U	W	P
62	NW	U	U	--	U	--	NW
63	NW	U	U	--	U	NW	NW
64	W	P	U	--	U	W	NW
65	NW	E	R	--	P	NW	NW
66	W	U	U	--	P	W	P
67	NW	U	U	--	U	NW	P
68	W	U	U	--	U	W	NW
69	W	U	U	--	U	W	NW
70	W	U	U	--	U	NW	NW
71	NW	U	U	--	U	NW	NW
72	W	U	U	--	U	W	--
73	NW	U	U	--	U	NW	P
74	NW	U	U	--	U	NW	NW
75	NW	U	U	--	U	NW	NW
76	NW	P	U	--	P	NW	--
77	NW	U	U	--	U	NW	NW
78	NW	U	U	--	U	NW	NW
79	W	P	U	--	U	W	NW
80	W	U	U	--	U	W	--

Table A4-2 (cont.)

Site	NRCS-NRI	NOAA-C-CAP	FWS-NWI	FWS-SAT	MD-WRA	NRCS-WI	Field
81	NW	U	U	--	U	NW	--
82	W	P	U	--	P	W	--
83	W	U	U	--	U	W	--
84	W	P	U	--	P	W	--
85	W	U	U	--	U	NW	NW
86	NW	P	U	--	U	NW	--
87	W	P	U	--	P	W	--
88	W	U	U	--	U	W	--
89	W	U	U	--	U	--	--
90	W	P	U	--	U	NW	--
91	W	P	U	--	U	NW	--
92	W	U	U	--	U	--	NW
93	NW	P	U	--	U	PC	NW
94	NW	P	U	--	U	--	--
95	W	U	U	--	U	W	--
96	W	U	U	--	U	W	NW
97	W	U	U	--	U	W	P
98	--	U	P	P	U	NW	NW
99	--	P	U	--	U	NW	--
100	--	U	U	--	P	NW	--
101	--	P	U	--	U	NW	NW
102	--	P	U	--	U	NW	NW
103	--	U	P	U	U	W	NW
104	--	P	U	--	U	W	--
105	--	U	P	--	P	NW	--
106	--	U	P	--	U	W	NW
107	--	U	P	--	P	W	P
108	--	U	P	--	U	W	--
109	--	P	P	--	U	W	--
110	--	P	U	--	U	W	--
111	--	U	L	--	L	NW	P
112	--	WA	L	--	L	W	P
113	--	U	P	--	U	W	P
114	--	U	P	--	U	W	P
115	--	P	U	--	P	W	P
116	--	P	U	--	U	W	NW
117	--	U	P	--	U	NW	NW
118	--	U	P	--	P	NW	P
119	--	U	P	--	U	W	NW
120	--	U	U	--	U	W	NW
121	--	U	U	--	P	W	P

Table A4-2 (cont.)

Site	NRCS-NRI	NOAA-C-CAP	FWS-NWI	FWS-SAT	MD-WRA	NRCS-WI	Field
122	--	P	U	--	U	W	NW
123	--	U	U	--	U	W	NW
124	--	U	U	--	U	W	NW
125	--	U	U	--	U	PC	NW
126	--	P	U	--	U	NW	NW
127	--	E	U	--	U	NW	NW
128	--	U	R	--	R	--	R
129	--	P	U	--	U	W	NW
130	--	P	U	--	U	W	NW
131	--	U	U	--	U	W	NW
132	--	P	P	--	P	W	P
133	--	P	U	--	U	W	NW
134	--	P	U	--	P	W	NW
135	--	P	U	--	U	W	P
136	--	U	U	--	U	W	NW
137	--	P	U	--	U	W	P
138	--	P	U	--	U	W	P
201	--	P	U	--	U	W	P
202	--	P	U	--	U	NW	NW
203	--	P	U	--	U	NW	--
204	--	P	U	--	P	NW	NW
205	--	P	U	--	U	NW	NW
206	--	P	U	--	U	NW	--
207	--	P	U	--	U	W	--
208	--	P	U	--	U	W	--
209	--	P	U	--	U	W	--
210	--	P	U	--	U	W	--
211	--	P	U	--	P	NW	NW
212	--	P	U	--	U	W	P
301	--	U	U	--	U	FW	NW
302	--	U	U	--	U	FW	NW
303	--	U	U	--	U	FW	NW
304	--	U	U	--	U	FW	NW
305	--	U	U	--	U	FW	P
306	--	U	U	--	U	FW	P
307	--	U	U	--	P	W	P
308	--	U	U	--	U	FW	NW
309	--	U	U	--	U	FW	--
310	--	U	U	--	U	FW	P
311	--	U	U	--	U	NW	NW
312	--	U	U	--	P	PC	NW

Table A4-2 (cont.)

Site	NRCS-NRI	NOAA-C-CAP	FWS-NWI	FWS-SAT	MD-WRA	NRCS-WI	Field
313	--	U	U	--	U	NW	NW
314	--	U	U	--	U	FW	P
315	--	U	U	--	U	PC	P
316	--	U	U	--	U	FW	P
317	--	U	U	--	U	FW	NW
318	--	U	U	--	U	FW	P
319	--	U	U	--	P	FW	NW
320	--	U	U	--	U	FW	NW
321	--	U	U	--	U	FW	P
322	--	U	U	--	U	PC	NW
323	--	U	U	--	U	PC	NW
324	--	U	U	--	U	FW	P
325	--	U	U	--	U	W	NW
326	--	U	U	--	U	PC	NW
327	--	U	U	--	U	PC	NW
328	--	U	U	--	U	PC	NW
329	--	U	U	--	U	PC	NW
330	--	U	U	--	U	FW	NW
331	--	U	U	--	U	PC	NW

Summary of Site Visits, Field Test 2
Wicomico County, Maryland
July 13-14, 1993
Table A4-3

Site A
Wango NE
July 14, 1993
Entered from State Route 350 at 210 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100′	Wet	Hydric	Upland	Upland	Wet	Wet
200′	Wet	Hydric	Upland	Upland	Wet	Wet

Site A1
Wango NE
July 14, 1993
Entered from State Route 350 at 40 degrees 2,000′ E of Site A

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100′	Trans	Hydric	Upland	Upland	Upland	Wet
200′	Trans	Hydric	Upland	Upland	Upland	Wet

Site B
Delmar NE
July 13, 1993
Entered from Rum Ridge Road at 305 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
200′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
300′	Wet	Hydric	Upland	Wet PFO1/4A	Wet (9)	Wet
400′	Wet	Hydric	Upland	Wet PFO1/4A	Wet (9)	Wet
500′	Wet	Hydric	Upland	Wet PFO1/4A	Wet (9)	Wet
600′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
700′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
800′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
900′	Trans	Trans	Upland	Upland	Wet (9)	Upland
1,000′	Trans	Trans	Upland	Upland	Wet (9)	Upland
1,100′	Upland	Not hyd	Upland	Upland	Wet (9)	Upland
1,200′	Upland	Not hyd	Upland	Upland	Wet (9)	Upland
1,300′	Trans	Not hyd	Upland	Upland	Wet (9)	Upland
1,400′	Trans	Hydric	Upland	Upland	Wet (9)	Upland
1,500′	Wet	Hydric	Upland	Upland	Wet (9)	Upland
1,600′	Wet	Hydric	Wet PFO1A	Wet PFO1C	Wet (9)	Upland
1,700′	Wet	Hydric	Upland	Wet PFO1C	Wet (9)	Upland
1,800′	Upland	Not hyd	Upland	Upland	Wet (9)	Upland
1,900′	Wet	Hydric	Upland	Upland	Wet (9)	Wet
2,000′	Trans	Hydric	Upland	Upland	Upland (7)	Wet
2,100′	Upland	Hydric	Upland	Upland	Upland (7)	Wet
2,200′	Wet	Hydric	Upland	Upland	Upland (7)	Wet

Site B
Delmar NE
July 13, 1993
Entered from Rum Ridge Road at 125 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100′	Upland	Not hyd	Upland	Upland	Wet (9)	Wet
200′	Trans	Hydric	Upland	Upland	Upland (7)	Wet
300′	Upland	Hydric	Upland	Upland	Upland (7)	Wet
400′	Upland	Not hyd	Wet PFO1C	Upland	Wet (9)	Wet
500′	Wet	Hydric	Wet PFO1C	Wet PFO1C	Wet (9)	Wet
600′	Wet	Hydric	Wet PFO1C	Wet PFO1C	Wet (9)	Wet
700′	Wet	Hydric	Upland	Wet PFO1C	Wet (9)	Wet
800′	Upland	Not hyd	Upland	Upland	Wet (9)	Wet

Site C
Delmar NE
July 13, 1993
Entered from Melson Road at 200 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100′	Upland	Not hyd	Upland	Upland	Wet (9)	Wet
Second	Upland	Hydric	Upland	Upland	Wet (9)	Wet
100′ West Parr to Road	Upland	Not hyd	Upland	Upland	Wet (9)	Wet
100′ East Parr to Road	Upland	Not hyd	Upland	Upland	Wet (9)	Upland

Site C
Delmar NE
July 13, 1993
Entered from Melson Road at 80 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100' E down road; 80' in S	Upland	Not hyd	Upland	Upland	Wet (9)	Upland
200' E down road; 80' in S	Upland	Not hyd	Upland	Upland	Wet (9)	Upland
300' E down road; 80' in N	Upland	Not hyd	Upland	Upland	Wet (9)	Upland

Site D
Delmar NE
July 13, 1993
Entered from Rum Ridge Rd. 550' SE from interesect with Melson Rd.
East Side of Road

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100'	Upland	Not hyd	Upland	Upland	Upland (6)	Wet

Site D
Delmar NE
July 13, 1993
Entered from Rum Ridge Rd. 550' SE from intersect with Melson Rd.
West Side of Road

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100'	Upland	Not hyd	Upland	Upland	Wet (9)	Wet

Site E
Salisbury NE
July 14, 1993
Entered at Fooks Road at 194 degrees

	Field call	Field soil	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
400' from road--in at 285 deg 50' in	Trans	Hydric	Upland	Upland	Wet (9)	Wet
600' from road--in at 83 deg 50' in	Trans	Hydric	Wet PSS4A	Upland	Wet (9)	Wet
1,000' from road--in at 256 deg 100' in	Upland	Not hyd	Upland	Wet PFO1A	Wet (9)	Wet
1,200' from road--in at 240 deg 200' in	Upland	Not hyd	Upland	Upland	Wet (9)	Upland

Site F
Salisbury NE
July 14, 1993
Entered at Fooks Road 550' W of Site E -- North

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
300'	Trans	Hydric	Upland	Wet PFO1A	Upland (8)	Wet

Site G
Salisbury NE
July 14, 1993
Entered at Fooks Road 2650' W of Site E at 185 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100'	Drained	Hydric	Upland	Upland	Wet (9)	Wet
200'	Upland	Not hyd	Upland	Upland	Wet (9)	Wet

Site H
Hebron SE
July 14, 1993
Entered 300' W of Rockawalking Road at 198 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100'	Wet	Hydric	Upland	Wet PFO1A	Upland (7)	Wet
200'	Wet	Hydric	Wet PFO1A	Wet PFO1A	Upland (7)	Wet
300'	Wet	Hydric	Wet PFO1A	Upland	Upland (7)	Wet
400'	Trans	Hydric	Wet PFO1A	Upland	Upland (5)	Upland

Site I
Hebron SE
July 14, 1993
Entered at Brick Kiln road at 240 degrees

	Field call	Field soils	FWS-NWI	MD-WRA	NOAA-C-CAP	NRCS-WI
100'	Wet (Borrow pit)	Hydric	Upland	Upland	Upland (7)	Wet
50' NW	Upland	Not hyd	Upland	Upland	Upland (5)	Upland
150' NW	Upland	Not hyd	Upland	Upland	Upland (7)	Wet